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UNITED STATES
DEPARTMENT OF THE INTERIOR
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HELIUM RESEARCH CENTER

INTERNAL REPORT

THE MEASUREMENT OF DIELECTRIC CONSTANTS
FOR BINARY GAS MIXTURES

BY

John L. Gordon

J. C. Franklin

BRANCH Branch of Fundamental Research

PROJECT NO. 6910

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THE MEASUREMENT OF DIELECTRIC CONSTANTS FOR BINARY GAS MIXTURES

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John L. Gordon[1/] and J. C. Franklin[1/]

ABSTRACT

This report describes the apparatus and operating procedures presently being used to determine dielectric constants for gases and gas mixtures to 65 atmospheres from 35° to -20° C. Dielectric constants and Clausius-Mosotti functions are tabulated in an appendix for He-CO_2 mixtures at three temperatures in the range.

The apparatus provides data of sufficient accuracy for calculation of dielectric virial coefficients over wide temperature ranges in a region where little or no data are now available.

This report is intended to serve as an internal record of the equipment used and of the procedures followed to measure capacitance, pressure, and temperature.

INTRODUCTION

The principal purpose of this report is to describe operating procedures used by the Physical Properties Section in measuring dielectric constants for gas mixtures. Methods and procedures described are those

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used to obtain the data tabulated in the Appendix. The apparatus is described in detail, including recent modifications, and general operating procedures are discussed; however, details for operation of individual equipment components are referred to the appropriate instruction manuals. Procedures are described for in situ calibrations. Calibrations obtained from the National Bureau of Standards or from manufacturers are not elaborated.

The macroscopic dielectric constant (ϵ) of a gas is related to the polarizability of the gas molecules through the Clausius-Mosotti function,

$$CM = \frac{\epsilon-1}{\epsilon+2}\left(\frac{1}{\rho}\right) = \frac{4}{3}\pi N_o \chi^{(e)}, \qquad (1)$$

where ρ is the molar density, N_o is Avagadro's number, and $\chi^{(e)}$ is the polarizability for non-polar molecules. This expression can be expanded into an infinite series in ρ,

$$CM = A + B\rho + C\rho^2 + \cdots, \qquad (2)$$

with A, B, C,$\cdots$ designated as "dielectric virial coefficients;" and, in this form it can be treated to give information with respect to intermolecular forces. Application of this virial concept to the dielectric properties of molecules will be the subject of a later report.

Dielectric constants have been reported only for single-component gases (2, 4, 5, 7),[2/] primarily within the 20°-150° C range. The

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2/ Underlined numbers in parentheses refer to items in the list of references at the end of this report; references 9-16 list pertinent manufacturer instruction manuals.

dielectric constant data reported here include binary mixtures of $He-CO_2$ and both pure components at 20°, 0°, and -10° C.

Gas mixtures were prepared by the Branch of Laboratory Services from grade-A helium (99.995%) and commercially available carbon dioxide (99.95%) with no further purification. These mixtures were analyzed by mass spectrometry to an accuracy of 0.1 mole percent.

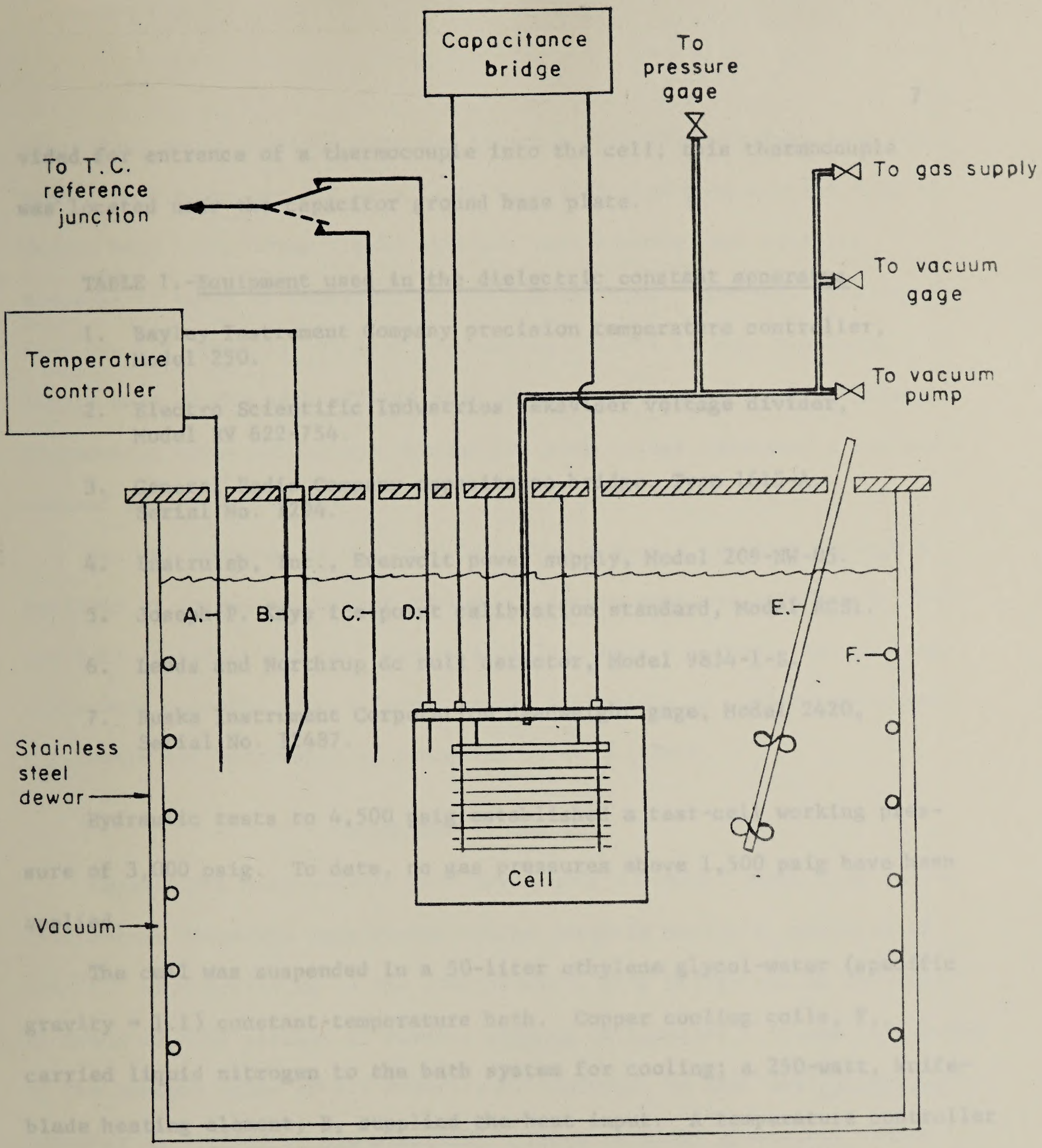
DESCRIPTION OF APPARATUS

Dielectric constants were determined by measuring the capacitance of a rigid, parallel-plate capacitor with (1) a vacuum dielectric, and (2) a gaseous dielectric at a known temperature, pressure, and composition. The apparatus is shown in block diagram in figure 1. Specific equipment

FIGURE 1.-Block diagram of dielectric constant apparatus.

components are listed in table 1. A 100-picofarad (pf) General Radio[3/] type 1404-B reference standard capacitor (12) was removed from its hermetic can and mounted in a high-pressure test cell machined from 316 stainless steel. The capacitor was rigidly fixed to the top cap or lid of the cell, and coaxial lead wires were passed through the lid by means of two separate high-pressure packing glands. Three-terminal electrical connections were retained throughout the capacitance system. The cell lid was threaded into the cell, and a seal made by O-ring compression. Copper tubing connections allowed gas inlet and evacuation. A packing gland pro-

3/ References to specific equipment used are made to facilitate understanding and do not imply endorsement by the Bureau of Mines.



A. Temperature sensor

B. 250 watt heater

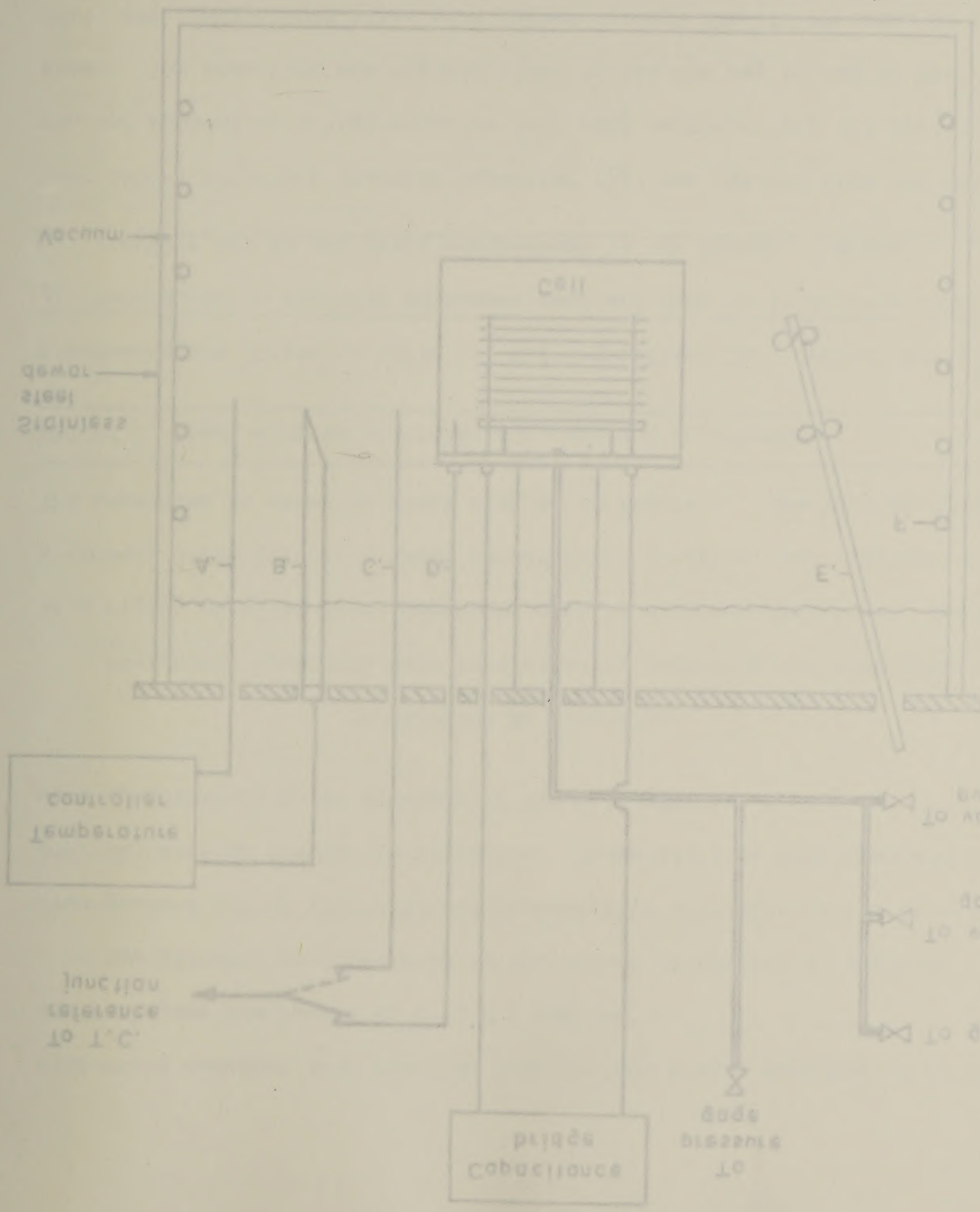
C. Bath thermocouple

D. Cell thermocouple

E. Bath stirrer

F. Cooling coils

FIGURE 1. – Block Diagram of Dielectric Constant Apparatus.


A
B
C
D
E
Cell
Vacuum
Stirrer
To capacitance bridge
To vacuum pump
To vacuum gage
To gas supply
To T.C. reference junction
Temperature controller

vided for entrance of a thermocouple into the cell; this thermocouple was located near the capacitor ground base plate.

TABLE 1.-Equipment used in the dielectric constant apparatus

1. Bayley Instrument Company precision temperature controller, Model 250.
2. Electro Scientific Industries dekavider voltage divider, Model RV 622-754.
3. General Radio Company capacitance bridge, Type 1615-A, Serial No. 1294.
4. Instrulab, Inc., Evenvolt power supply, Model 209-NW-05.
5. Joseph P. Kaye ice-point calibration standard, Model RCS1.
6. Leeds and Northrup dc null detector, Model 9834-1-S.
7. Ruska Instrument Corporation deadweight gage, Model 2420, Serial No. 12487.

Hydraulic tests to 4,500 psig established a test-cell working pressure of 3,000 psig. To date, no gas pressures above 1,500 psig have been applied.

The cell was suspended in a 50-liter ethylene glycol-water (specific gravity = 1.1) constant-temperature bath. Copper cooling coils, F, carried liquid nitrogen to the bath system for cooling; a 250-watt, knife-blade heating element, B, supplied the heat input. A temperature controller (9) with nickel temperature sensor, A, adjusted the heater output to balance the cooling rate. The bath held a set temperature to within ±0.005° C. A steel lid on the dewar supported the suspended cell and all control equipment except the cooling coils and a double-propeller stirring shaft. An

air-driven motor provided vigorous stirring with low heat leak into the bath. Both dewar and lid were later insulated with polyurethane foam to reduce heat leak, lower liquid nitrogen requirements, and minimize atmospheric water condensation at low temperatures. However, this insulation was not essential to good temperature control because the large liquid mass of the bath offered high inertia to temperature fluctuations. Thermometer-probe excursions through the bath volume indicated a maximum thermal gradient of 0.004° C.

Gas was admitted to the test cell from a supply cylinder through a manifold of valves and copper tubing. A vacuum pump was attached to this manifold to reduce the cell pressure to less than 0.1 Torr. Vacuum pressures were measured with a Pirani gage. Variations in vacuum capacitance, C_{vac}, were not observable at pressures below 0.1 Torr.

OPERATING PROCEDURES

Capacitance measurements were taken with a General Radio type 1615-A transformer ratio-arm capacitance bridge assembly having a precision of 1×10^{-4} pf. According to the manufacturer, this bridge has an absolute accuracy of 0.01 percent of reading without calibration. It was calibrated at the nominal value of all capacitance readings, so that its calibrated accuracy is limited by its precision. Three-terminal electrical connections and a dissipation-balancing network reduced lead capacitance and stray induction effects to a negligible level.

Before an initial capacitance was taken, the cell was evacuated and purged thoroughly, then re-evacuated for approximately 20 minutes to allow all gas to be removed (0.1 Torr) and to establish temperature equilibrium with the bath. When the bath and cell thermocouples indicated the same temperature, the vacuum capacitance (C_{vac}) was recorded. Repeating this procedure assured precision of reading corresponding to the bridge precision.

The dissipation factor, D, was measured simultaneously with gas capacitance, C, in the process of obtaining final capacitance balance on the bridge. D is a measure of the dissipative capacitance loss across a capacitor and along all associated electrical leads and connectors. D was quite small and did not affect the capacitance value if balanced by the bridge; that is, when the bridge was balanced with respect to D, there was no phase loss across the capacitor under measurement. Imbalance with respect to D resulted in a loss of bridge sensitivity to capacitance.

In all reported measurements, D was less than 10×10^{-6}. If any reading showed a D larger than this figure, purging was continued. A very large D ($> 100 \times 10^{-6}$) invariably indicated a gas leak in the test cell or a liquid leak into a coaxial lead. Tests showed that D values as high as 20×10^{-6} did not affect the capacitance reading. All vacuum capacitance measurements had values of D less than 5×10^{-6}; most were less than 1×10^{-6}.

After the desired gas mixture was admitted into the cell, and temperature stability had been regained, C was recorded. Repeatability tests

were made by evacuating and refilling to approximately the same pressure.

Bath and cell temperatures were recorded as thermocouple millivolt (mv) readings. The thermocouples were copper-constantan referenced to an electronic ice bath (14) and calibrated as indicated under Calibration Procedures. Millivolt readings were converted to Celsius degrees through a calibration table. Interpolation errors were not present, because the calibrations were performed at precisely those temperatures to be used as isotherms. The electronic ice bath was stable to 0.001° C, referenced to the triple-point of water.

Figure 2 is a schematic diagram of the thermocouple system. The

FIGURE 2.-Diagram of thermocouple system.

output from a constant 100-mv dc power supply (13) was attenuated by a precision 6-dial Kelvin-Varley voltage divider (10) until the resultant voltage exactly matched the thermocouple voltage. Balance was indicated by a null detector (15). The divider dial reading was recorded as the thermocouple voltage. This entire system was electrically floated above ground potential, and was calibrated *in situ*. Temperatures are reported in the International Practical Temperature Scale and are considered accurate to 0.01° C.

Initially, pressures were measured with a 0-5,000 psia strain gage pressure transducer, and all pressures reported in the Appendix were thus obtained. A constant 10-volt dc power supply (13) was used, and both the power supply and transducer were maintained at 35°±0.5° C in an incubation oven. The transducer was calibrated *in situ* by taking parallel pressure

FIGURE 5.-Diagram of thermocouple system.

Figure 5 is a schematic diagram of the thermocouple system. The triple-point of water

accurate to 0.01° C.

In the International Practical Temperature Scale and are considered

strong potential, and were calibrated $\overline{\mu}$ $\overline{\text{with}}$. Temperatures are reported

thermocouple voltage. This emitter system was electrically floated above

by a null detector ($\overline{12}$). The digital result was recorded as the

voltage exactly matched the thermocouple voltage. Balance was indicated

precision 6-digit Kelvin-Weston voltage divider ($\overline{10}$) until the resultant

output from a constant 100-ma dc power supply ($\overline{13}$) was attenuated by a

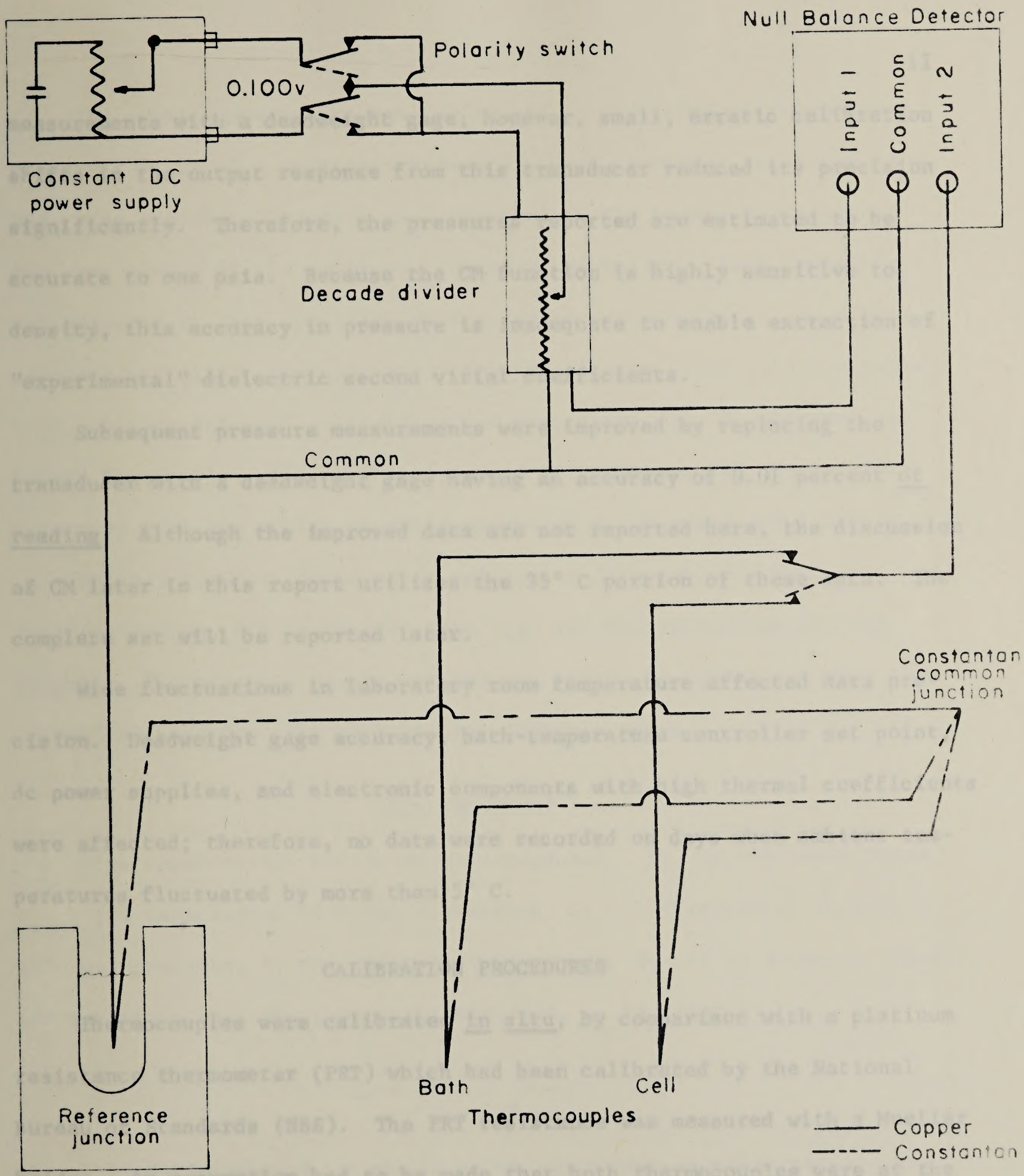
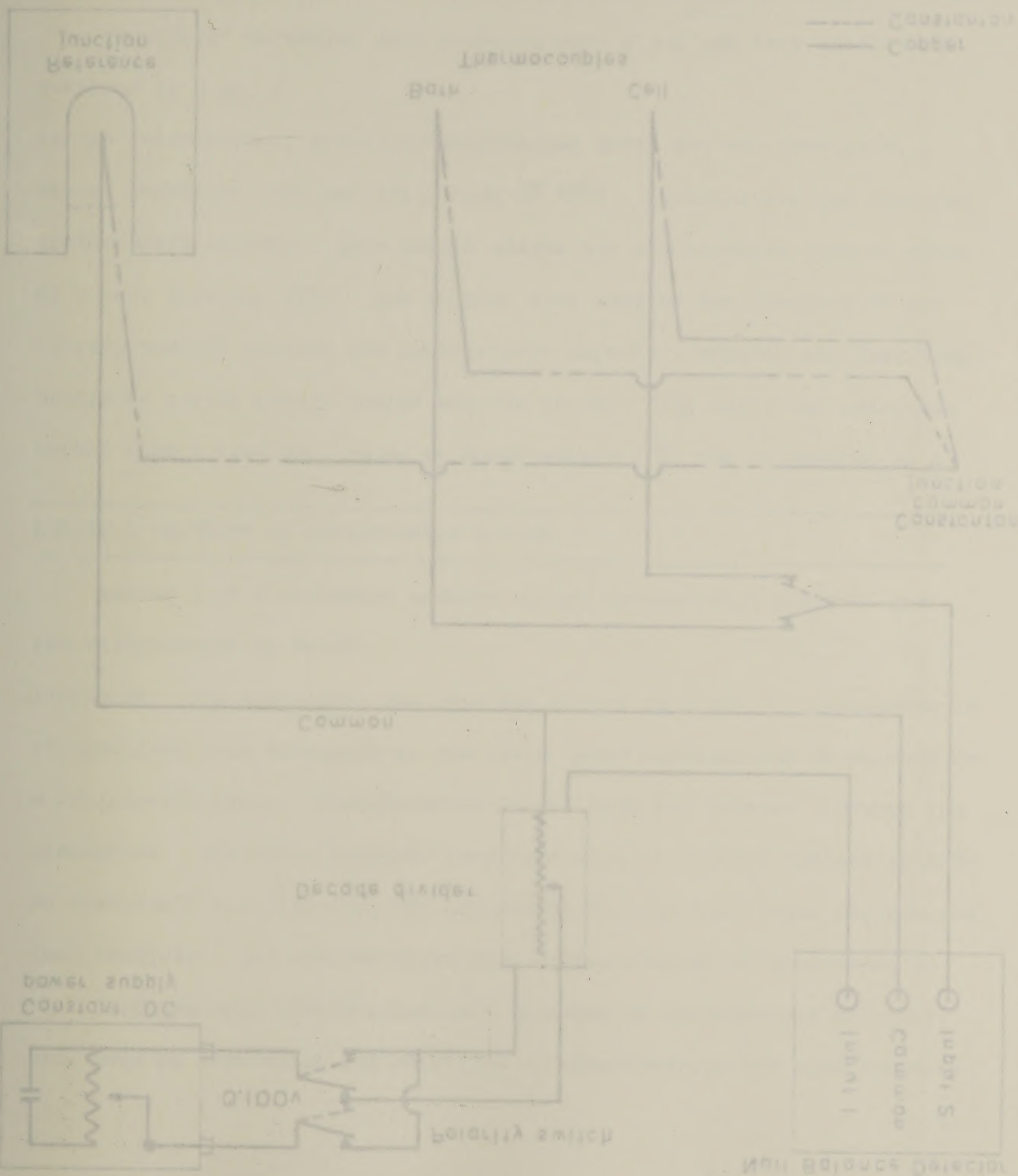


FIGURE 2. - Diagram of Thermocouple System.


Reference
Junction
Thermocouples
Bath
Cell
Common
Decade divider
0.1000V
Polarity switch
Constant DC
power supply
Null Balance Detector
Signal
Control
Signal

measurements with a deadweight gage; however, small, erratic calibration shifts in the output response from this transducer reduced its precision significantly. Therefore, the pressures reported are estimated to be accurate to one psia. Because the CM function is highly sensitive to density, this accuracy in pressure is inadequate to enable extraction of "experimental" dielectric second virial coefficients.

Subsequent pressure measurements were improved by replacing the transducer with a deadweight gage having an accuracy of 0.01 percent of reading. Although the improved data are not reported here, the discussion of CM later in this report utilizes the 35° C portion of these data. The complete set will be reported later.

Wide fluctuations in laboratory room temperature affected data precision. Deadweight gage accuracy, bath-temperature controller set point, dc power supplies, and electronic components with high thermal coefficients were affected; therefore, no data were recorded on days when ambient temperatures fluctuated by more than 5° C.

CALIBRATION PROCEDURES

Thermocouples were calibrated in situ, by comparison with a platinum resistance thermometer (PRT) which had been calibrated by the National Bureau of Standards (NBS). The PRT resistance was measured with a Mueller bridge. An assumption had to be made that both thermocouples were at the same temperature when a calibration was made; therefore, the bath was regulated and held constant for more than two hours before making readings. The error due to this assumption is considered to be negligible, but has not been measured.

The capacitance bridge was calibrated by adjusting it to indicate the exact value of a reference standard 100-pf capacitor certified by NBS. The reference standard was connected to the bridge terminals in the same manner as the test-cell "unknown" capacitor. Room temperature was adjusted to that specified on the capacitor certificate, or a temperature correction was applied to the capacitance value before calibration. Bridge internal autocalibration procedures (11, p. 49) were performed frequently. All calibrations and all experimental measurements were made with the bridge assembly operating at 30 volts and 1,000 Hz.

Ruska Instrument Corporation calibrated (traceable to NBS) the rotating-piston, oil deadweight gage (16) and the associated loading weights. The pressure transducer was calibrated by comparison with this deadweight gage over the experimental pressure range.

DATA TREATMENT

Five experimental variables were measured: (1) vacuum capacitance, C_{vac}; (2) capacitance with gas dielectric, C; (3) dissipation factor, D; (4) gas pressure, P; and (5) cell temperature, T. It is shown in standard textbooks that the dielectric constant, ϵ, is given by

$$\epsilon = \frac{C}{C_{vac}} = \frac{\epsilon}{\epsilon_{vac}}, \tag{3}$$

where, by definition, ϵ_{vac} equals unity. Gas mixture molar density was calculated from the simple gas law,

$$\rho = \frac{P}{ZRT}, \tag{4}$$

$$b = \frac{\Sigma x_i}{n} \tag{4}$$

where Z is the compressibility factor and R is the universal gas constant. Weems and Miller (8) measured compressibility factors, Z, for each He-CO_2 mixture used in this study, at each isotherm reported and over the experimental range of pressures. Their smoothed Z's are claimed to be accurate to 0.1 percent. Comparison of their Z-data for CO_2 with those of Vukalovich, Kobelev, and Timoshenko (VKT)(6) and of their data for He with those of Miller, Brandt, and Stroud (3) and those of Briggs as treated by Dalton (1) showed agreement within 0.1 percent. Figure 3 shows this comparison

FIGURE 3.-Compressibility factors for carbon dioxide at 35° C.

for CO_2. When the CO_2 data of VKT were used to compute CM values, the CM vs ρ curve exhibited a minimum (fig. 4) which is not in accord with

FIGURE 4.-Clausius Mosotti for carbon dioxide at 35° C.

literature or previous experience. All He compressibility data gave essentially the same CM curve. The Z-data by Weems and Miller were used to compute densities from equation 4.

Table 2 and figures 4 and 5 are not based on the data in the Appendix. They represent the more accurate data taken after converting to deadweight pressure measurements. The Clausius-Mosotti functions shown in table 2 were calculated by fitting the isothermal, constant composition dielectric constants, ε-1, to a quadratic in the density, ρ:

$$\varepsilon - 1 = b\rho + c\rho^2. \qquad (5)$$

Substitution of equation 5 into equation 1 gives

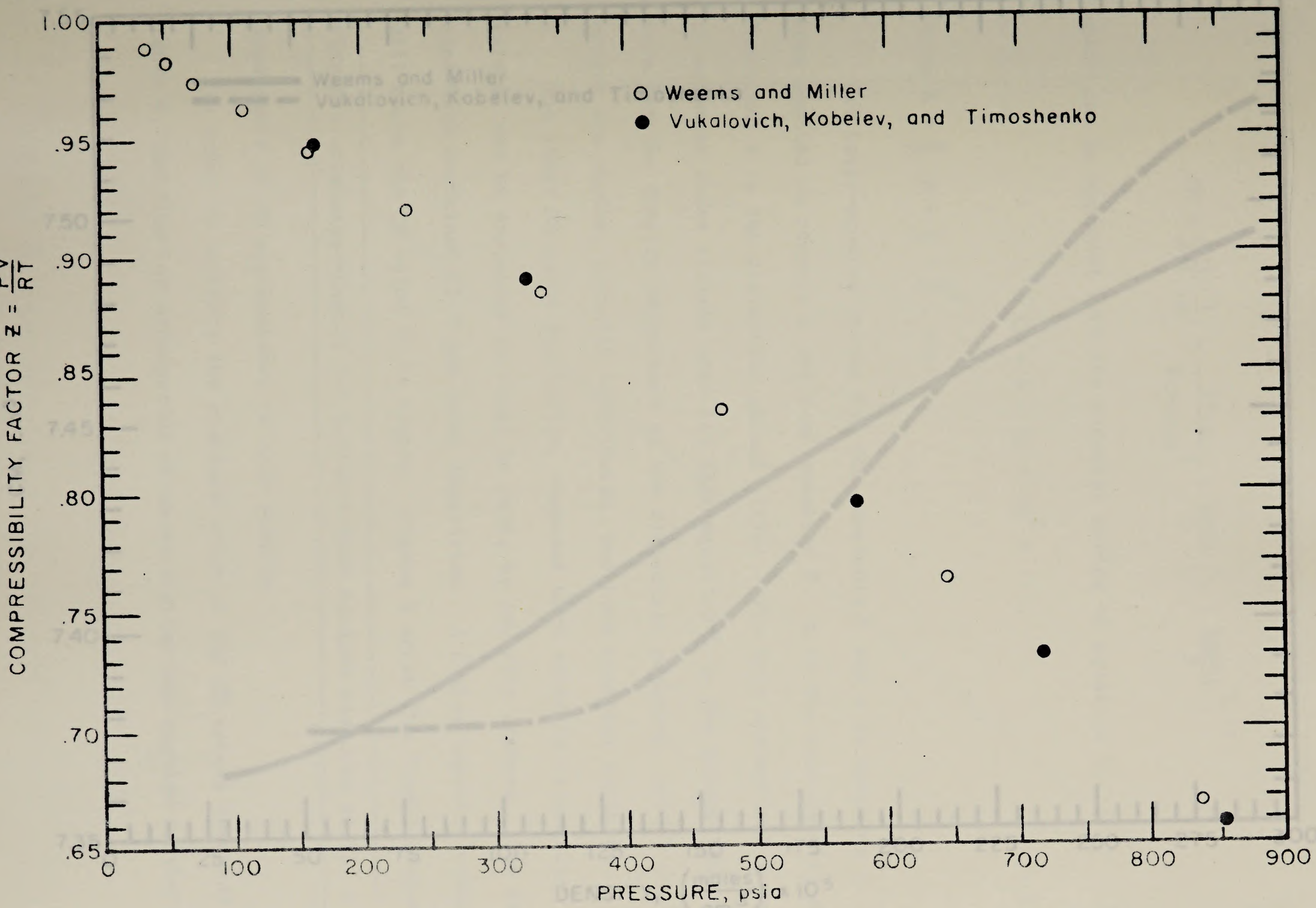


FIGURE 3 — Compressibility Factors For Carbon Dioxide at 35°C.

PRESSURE, atm
0
100
200
300
400
500
600
700
800
900
1.00
.95
.90
.85
.80
.75
.70
COMPRESSIBILITY FACTOR = $\frac{PV}{RT}$
Wegwo and Miller
Vukolovich, Kopelev, and Timofeyeva

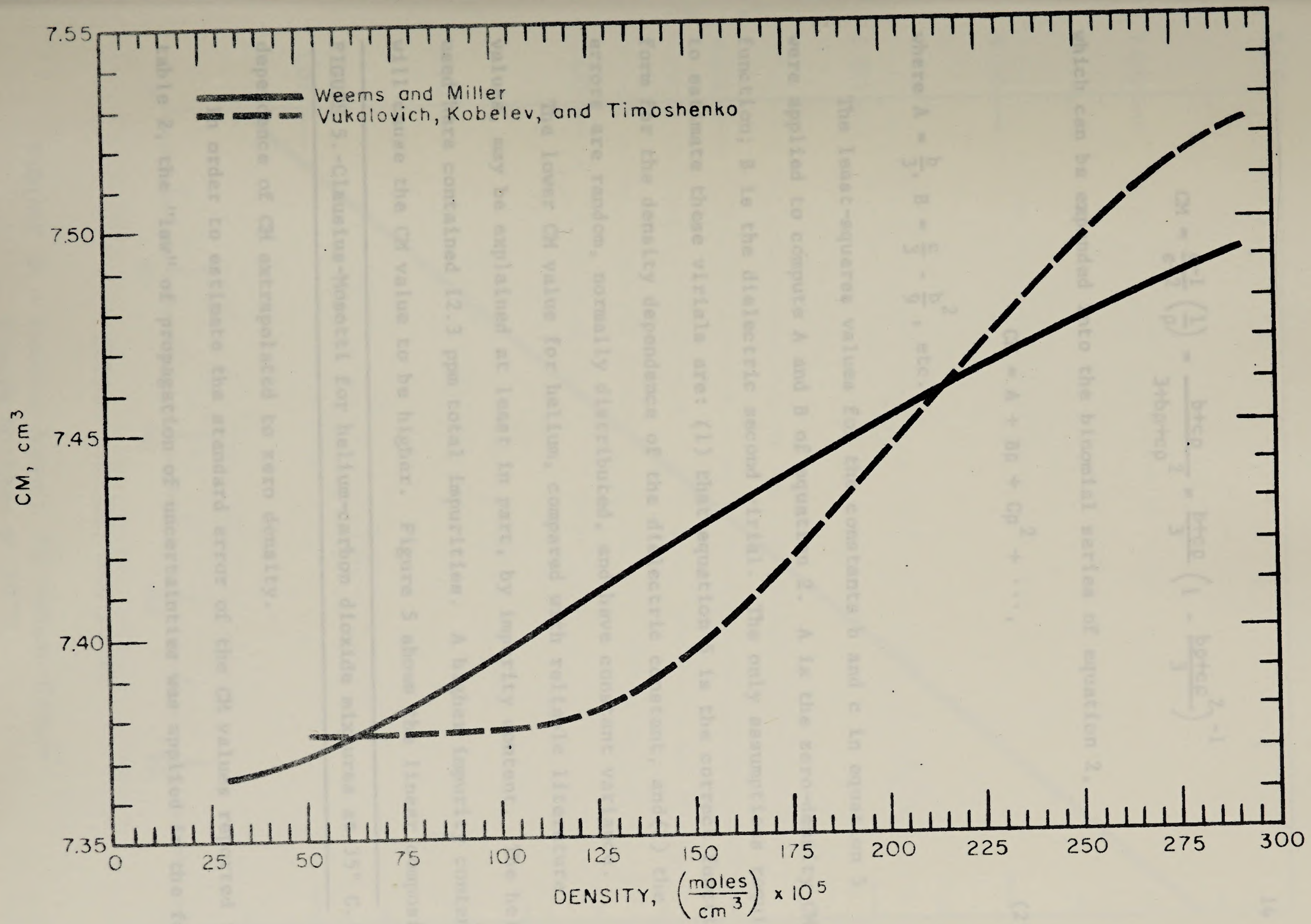
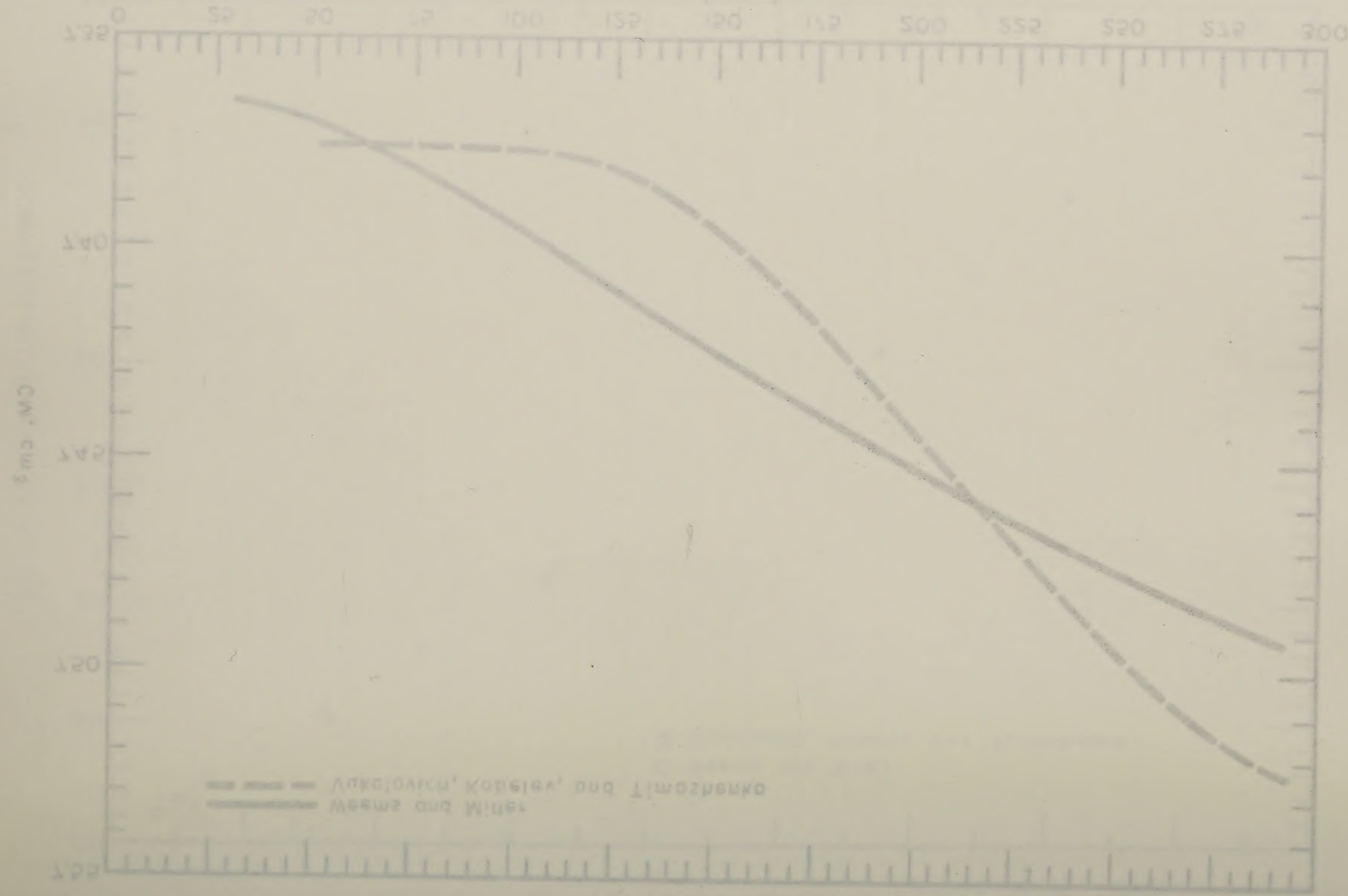


FIGURE 4. – Clausius Mosotti For Carbon Dioxide at 35°C.



$$CM = \frac{\epsilon-1}{\epsilon+2}\left(\frac{1}{\rho}\right) = \frac{b+c\rho}{3+b\rho+c\rho^2} = \frac{b+c\rho}{3}\left(1 - \frac{b\rho+c\rho^2}{3}\right)^{-1}$$

which can be expanded into the binomial series of equation 2,

$$CM = A + B\rho + C\rho^2 + \cdots, \qquad (2)$$

where $A = \frac{b}{3}$, $B = \frac{c}{3} - \frac{b^2}{9}$, etc.

The least-squares values for the constants b and c in equation 5 were applied to compute A and B of equation 2. A is the zero-density CM function; B is the dielectric second virial. The only assumptions required to estimate these virials are: (1) that equation 5 is the correct functional form for the density dependence of the dielectric constant, and(2) the errors are random, normally distributed, and have constant variance.

The lower CM value for helium, compared with reliable literature values, may be explained at least in part, by impurity content. The helium used here contained 12.3 ppm total impurities. A higher impurity content will cause the CM value to be higher. Figure 5 shows the linear composition

FIGURE 5.-Clausius-Mosotti for helium-carbon dioxide mixtures at 35° C.

dependence of CM extrapolated to zero density.

In order to estimate the standard error of the CM values reported in table 2, the "law" of propagation of uncertainties was applied in the form

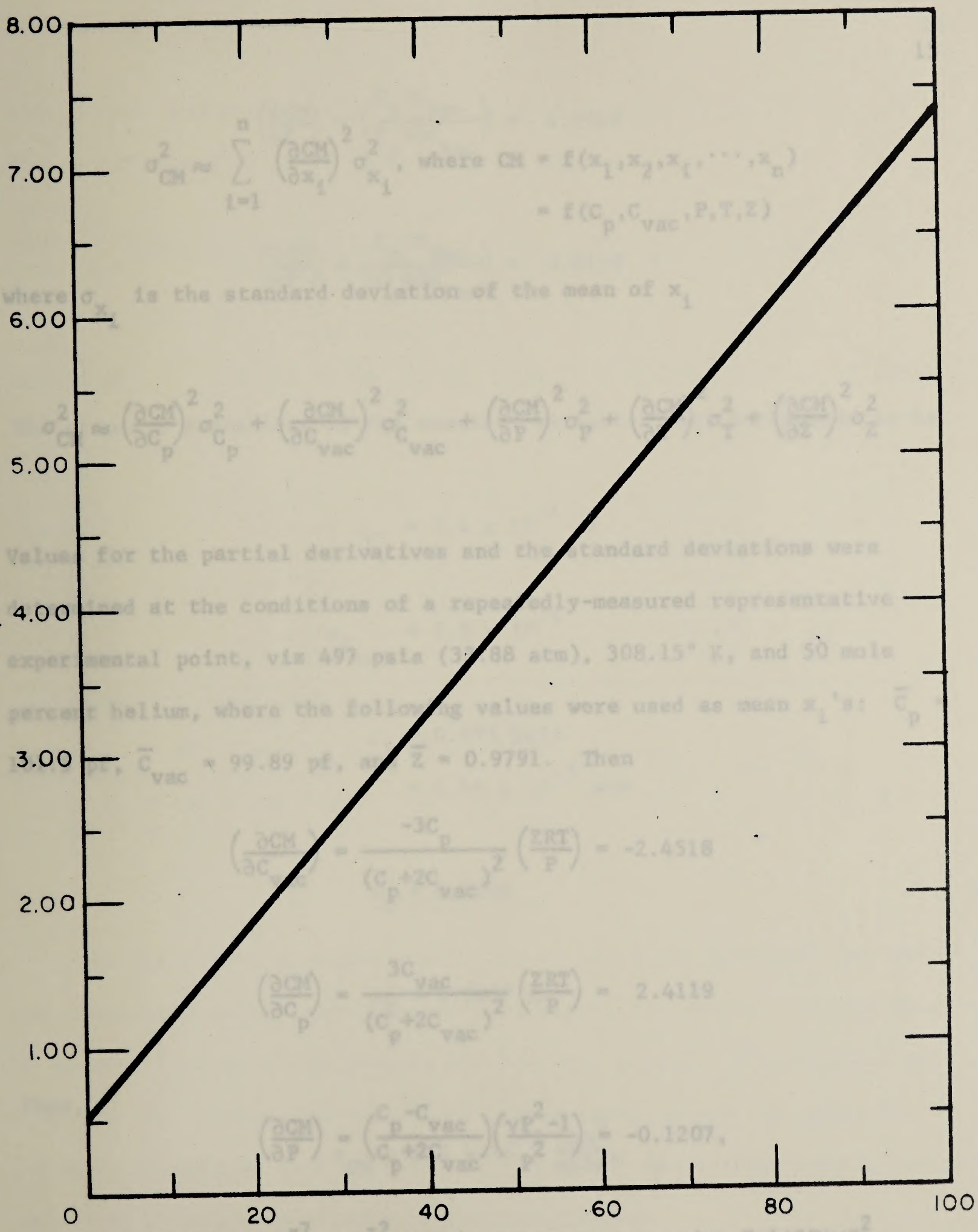
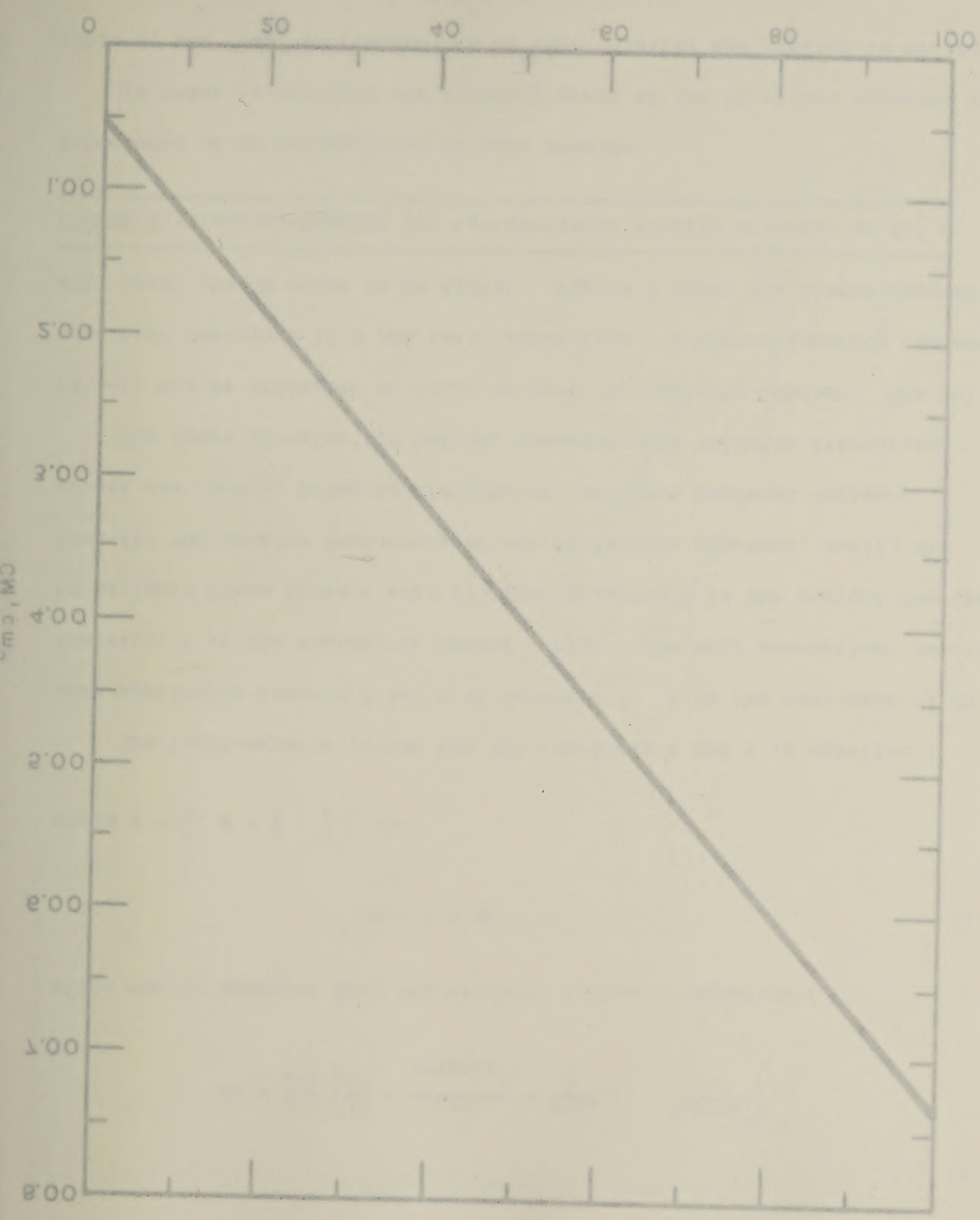


FIGURE 5. – Clausius–Mosotti For Helium–Carbon Dioxide Mixtures at 35°C.

FIGURE 2. - Clausius-Mosotti For Helium-Carbon Dioxide Mixtures at 32°C.



$$\sigma_{CM}^2 \approx \sum_{i=1}^{n} \left(\frac{\partial CM}{\partial x_i}\right)^2 \sigma_{x_i}^2, \text{ where } CM = f(x_1, x_2, x_i, \cdots, x_n)$$
$$= f(C_p, C_{vac}, P, T, Z)$$

where σ_{x_i} is the standard deviation of the mean of x_i

$$\sigma_{CM}^2 \approx \left(\frac{\partial CM}{\partial C_p}\right)^2 \sigma_{C_p}^2 + \left(\frac{\partial CM}{\partial C_{vac}}\right)^2 \sigma_{C_{vac}}^2 + \left(\frac{\partial CM}{\partial P}\right)^2 \sigma_P^2 + \left(\frac{\partial CM}{\partial T}\right)^2 \sigma_T^2 + \left(\frac{\partial CM}{\partial Z}\right)^2 \sigma_Z^2$$

Values for the partial derivatives and the standard deviations were determined at the conditions of a repeatedly-measured representative experimental point, viz 497 psia (33.88 atm), 308.15° K, and 50 mole percent helium, where the following values were used as mean x_i's: $\bar{C}_p$ = 101.5 pf, $\bar{C}_{vac}$ = 99.89 pf, and $\bar{Z}$ = 0.9791. Then

$$\left(\frac{\partial CM}{\partial C_{vac}}\right) = \frac{-3C_p}{(C_p+2C_{vac})^2}\left(\frac{ZRT}{P}\right) = -2.4518$$

$$\left(\frac{\partial CM}{\partial C_p}\right) = \frac{3C_{vac}}{(C_p+2C_{vac})^2}\left(\frac{ZRT}{P}\right) = 2.4119$$

$$\left(\frac{\partial CM}{\partial P}\right) = \left(\frac{C_p - C_{vac}}{C_p+2C_{vac}}\right)\left(\frac{\gamma P^2 - 1}{P^2}\right) = -0.1207,$$

where $\gamma = 16.505 \times 10^{-7}$ atm^{-2} in the pressure expansion $Z = 1+\beta P+\gamma P^2$.

where $\gamma = 10^{-1}\ 202.18 \times 10^{-5}$ m^3 in the pressure expansion $Z=1+B\gamma+C\gamma^2+\ldots$

$$\left(\frac{\partial G}{\partial q}\right) = \left(\frac{C_{p,q}-C_{sav}}{S_q}\right)\left(\frac{S\gamma_v}{1-S\gamma_v}\right) = -0.1501,$$

$$\left(\frac{\partial G}{\partial p}\right)_q = \frac{S_{(sav}+SC_{p,q})}{SC_{sav}}\left(\frac{TRZ}{\gamma}\right) = 2.4114,$$

$$\left(\frac{\partial G}{\partial C_{sav}}\right) = \frac{S_{(sav}+SC_{p,q})}{-SC_q}\left(\frac{TRZ}{\gamma}\right) = -2.4248,$$

where $\bar{C}_{sav} = 98.99$ kJ, and $\bar{Z} = 0.1979$. Then

101.5 kJ, percent deficit, where the following values were used as mean x^I's: $\bar{C}_p =$

$$\left(\frac{\partial G}{\partial x^I}\right)_S = f(C_p, C_{sav}, q, T, Z)$$

$$= f(x_1, x_2, \ldots, x_n)$$

where x^I is the standard deviation of the mean of x^I

$$G^{MC}_S = \sum_{I=1}^{n}\left(\frac{\partial G}{\partial x^I}\right)_S G^{x^I}_S, \text{ where } CM = f(x^I, x^2, \ldots, x^n)$$

$$\left(\frac{\partial CM}{\partial Z}\right) = \left(\frac{C_p - C_{vac}}{C_p + 2C_{vac}}\right) = 4.0960$$

$$\left(\frac{\partial CM}{\partial T}\right) = \left(\frac{C_p - C_{vac}}{C_p + 2C_{vac}}\right) = 0.0130$$

The standard deviations of the measured variables were determined to be:

$$\sigma_{C_p} = 1.4 \times 10^{-4} \text{ pf}$$

$$\sigma_{C_{vac}} = 2.2 \times 10^{-4}$$

$$\sigma_P = 0.095 \text{ psia}$$

$$= 6.46 \times 10^{-3} \text{ atm}$$

$$\sigma_Z = 0.0005$$

$$\sigma_T = 0.003^\circ \text{ K}$$

Thus,

$$\sigma_{CM} \approx 2.3 \times 10^{-3} \frac{\text{cm}^3}{\text{mole}},$$

at the conditions stated, but not necessarily at any other point. Such a stipulation counters the required assumption stated above that the

mathematics require constant variance; however, the error due to this factor is estimated to be less than the standard error.

TABLE 2.-Clausius-Mosotti function at zero density, A, and related parameters for He-CO_2 mixtures at 35° C

Comp., mole % He	Equation 2		Equation 5	
	A, cm^3/mole	B, cm^6/mole	b, cm^3/mole	c, cm^6/mole
100.00	1/0.5169	0.36	1.55058	1.90072
94.52	.8903	1.89	2.67083	8.04008
89.80	1.2136	.28	3.64091	5.26211
74.30	2.2783	1.78	6.83479	20.90977
48.80	3.9903	15.36	11.97077	93.86374
24.58	5.6572	27.01	16.97154	177.0511
20.29	5.9643	28.93	17.89297	193.5145
7.50	6.8190	38.52	20.45703	255.0687
5.73	6.9529	41.61	20.85880	269.8743
0.00	2/7.3435	55.47	22.03037	328.1904

1/ Literature comparison:
ref 2, @ 23° C and 1 atm., CM = 0.5221
ref 5, @ 23° C and 1 atm., CM = .5225

2/ Literature comparison:
ref 4, @ 100°C and 1 atm., CM = 7.3460
ref 7, @ 25°C and 1 atm., CM = 7.3500

CONCLUSIONS

The dielectric constant apparatus, as presently operated, and without additional major improvements, is suitable for precise measurements of gaseous (and possibly liquid) dielectric constants. Capacitance and pressure can be measured easily and reproducibly, since replacing the pressure transducer with a deadweight gage; and these measurements can be made over wide ranges of temperature and pressure.

made over wide ranges of temperature and pressure.

pressure transducer with a designated span; and these measurements can be-

pressure can be measured easily and reproducibly, since replacing the

of gaseous (and nonconducting liquid) dielectric constants. Capacitance and

ont additional major improvements, is suitable for precise measurements

The dielectric constant approach, as presently observed, and virtu-

CONCLUSIONS

ref 7, @ 25.0 C and 1 atm., CM = 1.3200
ref 4, @ 100.0 C and 1 atm., CM = 1.3490
5\ Literature comparison:
ref 2, @ 25. C and 1 atm., CM = .2552
ref 3, @ 25. C and 1 atm., CM = 0.2551
1\ Literature comparison:

mole % He	A, cm^3\mole	B, cm^6\mole	C, cm^9\mole	D, cm^{12}\mole
Comb.*	Equation 3		Equation 2	
100.00	9\0.2169	0.36	1.22028	1.00012
84.80	3.0066	1.36	1.10769	.963844
74.20	2.7283	1.78	1.03648	.906406
64.85	2.4863	2.19	.968288	.851945
52.05	2.1523	2.79	.879403	.771211
44.28	1.9253	3.29	.815194	.715096
34.20	1.6783	3.89	.744838	.653806
28.80	1.5136	4.29	.698403	.612750
20.00	1.2691	5.09	.597488	.524205
15.00	1.1358	5.59	.542603	.476082
10.00	1.0025	6.09	.487319	.427638
5.00	.8692	6.59	.432035	.379194
2.50	.8026	6.84	.404393	.354972
1.00	.7627	7.00	.387903	.340500
0.00	9\.7432	7.09	.379751	.333350

TABLE 5.-Clausius-Mossotti function at zero density, A, and related parameters for He-CO_2 mixtures at 25° C

maximum error is estimated to be less than the standard error.

mathematical regular constant variance; however, the error due to this

Calculation of our CM values presently depends on the availability of gas mixture P-V-T data which are frequently lacking or of unknown reliability. Therefore, a modification to incorporate gas density measurements in conjunction with capacitance would be a worthwhile improvement. This was recommended and has been recommended for programing.

ACKNOWLEDGMENTS

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APPENDIX

Dielectric Constants of He-CO_2 Mixtures at 20°, 0°, and -10° C to 1,000 psia

The following tables record data, taken during 1967 and 1968, on the dielectric constants of gaseous mixtures of helium and carbon dioxide.

The dielectric constants are of high precision, but the pressure measurements were made with a pressure transducer having a 5,000-psia range and an accuracy of 0.1 percent of fullscale reading. Therefore, the CM values are of low precision. After testing the apparatus over these three isotherms, the pressure transducer was replaced with a high-precision deadweight gage before starting the next isotherm (35° C).

No experimental ϵ values have been reported in the literature for He-CO_2 mixtures. The density dependence of ϵ has not been studied below 50° C; therefore, the values tabulated below, although of relatively low precision, represent a first attempt to obtain data in a temperature-pressure-composition region not previously covered.

APPENDIX

Dielectric Constants of He-CO_2 Mixtures
at 50°, 0°, and -10° C to 1,000 bars

The following tables record data, taken during 1961 and 1968, on the dielectric constants of gaseous mixtures of helium and carbon dioxide. The dielectric constants are of high precision, but the pressure-composition region not previously covered.

Erection, represents a first attempt to obtain data in a temperature-

50° C; therefore, the values tabulated below, although of relatively low

He-CO_2 mixtures. The density dependence of a gas not been studied below

No experimental values have been reported in the literature for

precision necessary here before starting the next isotherm (32° C).

these cases, isotherms, the pressure transducer was replaced with a high-

the CM values are of low precision. After testing the apparatus over

range and an accuracy of 0.1 percent of full scale reading. Therefore,

measurements were made with a pressure transducer rated at 2,000-bars

The dielectric constants are of high precision, but the pressure

the dielectric constants of gaseous mixtures of helium and carbon dioxide.

TABLE 1.- Dielectric constants for $He-CO_2$ system at 20° C

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM_3, (cm^3)
	Composition 100% He		
965.314	264.51	1.004105	0.5166
962.540	263.77	1.004094	.5166
957.055	262.32	1.004071	.5166
949.581	260.33	1.004040	.5166
770.646	212.51	1.003301	.5173
754.411	208.14	1.003233	.5172
693.929	191.83	1.002979	.5171
604.168	167.51	1.002599	.5168
400.079	111.67	1.001726	.5148
205.592	57.75	1.000883	.5097
146.237	41.16	1.000629	.5093
77.026	21.73	1.000344	.5285
16.959	4.79	1.000065	.4527
95.776	27.00	1.000412	.5093
288.918	80.94	1.001254	.5162
473.769	131.92	1.002048	.5172
1005.450	275.15	1.004275	.5172
663.344	183.56	1.002851	.5172
518.527	144.17	1.002240	.5175
286.633	80.31	1.001242	.5153
64.406	18.18	1.000272	.4995
39.788	11.24	1.000164	.4872
368.660	103.01	1.001582	.5119
467.882	130.31	1.002009	.5137
701.001	193.74	1.003034	.5215
823.121	226.59	1.003545	.5209
823.941	226.81	1.003548	.5208
775.196	213.73	1.003336	.5197
688.622	190.40	1.002970	.5194
191.317	53.77	1.000836	.5183
24.155	6.82	1.000117	.5722
23.758	6.71	1.000115	.5718
130.624	36.78	1.000572	.5181
527.534	146.63	1.002351	.5340
744.616	205.51	1.003270	.5298
640.689	177.43	1.002820	.5293
385.524	107.66	1.001710	.5291

Fraction (beta)	Density, ρ (moles/cm^3) x 10^2	Dielectric constant	C_M (cm)
	composition 100% H_2		
0.2195	1.000502	1.004100	312.4
.2198	1.004064	1.016400	312.5
.2199	1.004040	1.016100	312.6
.2200	1.004016	1.015800	312.7
.2201	1.003992	1.015500	312.8
.2202	1.003968	1.015200	312.9
.2203	1.003944	1.014900	313.0
.2204	1.003920	1.014600	313.1
.2205	1.003896	1.014300	313.2
.2206	1.003872	1.014000	313.3
.2207	1.003848	1.013700	313.4
.2208	1.003824	1.013400	313.5
.2209	1.003800	1.013100	313.6
.2210	1.003776	1.012800	313.7
.2211	1.003752	1.012500	313.8
.2212	1.003728	1.012200	313.9
.2213	1.003704	1.011900	314.0
.2214	1.003680	1.011600	314.1
.2215	1.003656	1.011300	314.2
.2216	1.003632	1.011000	314.3
.2217	1.003608	1.010700	314.4
.2218	1.003584	1.010400	314.5
.2219	1.003560	1.010100	314.6
.2220	1.003536	1.009800	314.7
.2221	1.003512	1.009500	314.8
.2222	1.003488	1.009200	314.9
.2223	1.003464	1.008900	315.0
.2224	1.003440	1.008600	315.1
.2225	1.003416	1.008300	315.2
.2226	1.003392	1.008000	315.3
.2227	1.003368	1.007700	315.4
.2228	1.003344	1.007400	315.5
.2229	1.003320	1.007100	315.6
.2230	1.003296	1.006800	315.7
.2231	1.003272	1.006500	315.8
.2232	1.003248	1.006200	315.9
.2233	1.003224	1.005900	316.0
.2234	1.003200	1.005600	316.1
.2235	1.003176	1.005300	316.2
.2236	1.003152	1.005000	316.3
.2237	1.003128	1.004700	316.4
.2238	1.003104	1.004400	316.5
.2239	1.003080	1.004100	316.6
.2240	1.003056	1.003800	316.7
.2241	1.003032	1.003500	316.8
.2242	1.003008	1.003200	316.9
.2243	1.002984	1.002900	317.0
.2244	1.002960	1.002600	317.1
.2245	1.002936	1.002300	317.2
.2246	1.002912	1.002000	317.3
.2247	1.002888	1.001700	317.4
.2248	1.002864	1.001400	317.5
.2249	1.002840	1.001100	317.6
.2250	1.002816	1.000800	317.7
.2251	1.002792	1.000500	317.8
.2252	1.002768	1.000200	317.9
.2253	1.002744	1.000000	318.0

TABLE I.- Dielectric constants for H_2-CO_2 mixtures at 30° C

TABLE 1.- Dielectric constants for $He-CO_2$ system at 20° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM_3, (cm^3)
	Composition 100% He		
117.233	33.03	1.000516	0.5215
34.254	9.67	1.000155	.5347
19.366	5.47	1.000084	.5123
22.976	6.49	1.000113	.5810
983.211	269.26	1.004199	.5191
906.329	284.82	1.003881	.5192
859.326	236.28	1.003702	.5217
799.536	220.27	1.003453	.5219
32.641	9.22	1.000179	.6480
27.616	7.80	1.000124	.5305
52.457	14.81	1.000232	.5229
72.236	20.38	1.000319	.5225
91.930	25.92	1.000405	.5216
83.963	23.68	1.000370	.5216
63.004	17.78	1.000294	.5519
63.004	17.78	1.000276	.5181
41.004	11.58	1.000179	.5160
19.837	5.60	1.000083	.4942
34.130	9.64	1.000140	.4847
52.296	14.76	1.000223	.5042
71.206	20.09	1.000309	.5134
93.394	26.33	1.000408	.5172
113.125	31.88	1.000494	.5173
133.119	37.48	1.000583	.5183
153.150	43.10	1.000671	.5189
168.566	47.41	1.000739	.5196
187.991	52.84	1.000825	.5205
210.880	59.23	1.000926	.5213
202.737	56.96	1.000890	.5210
181.909	51.14	1.000798	.5202
159.728	44.94	1.000700	.5192
141.757	39.91	1.000620	.5178
122.595	34.53	1.000534	.5162
101.609	28.64	1.000440	.5128
82.374	23.23	1.000355	.5100

Propellant	Density (gm/cm^3)	Dielectric constant	Combustion loss $\times 10^2$ (gm/cm^2) (hr)

TABLE 1.- Dielectric constants for $He-CO_2$ system at 20° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM_3, (cm^3)
	Composition 100% He		
58.909	16.63	1.000251	0.5039
40.024	11.30	1.000165	.4872
62.346	17.59	1.000259	.4913
112.033	31.57	1.000475	.5023
161.429	45.41	1.000691	.5072
212.320	59.63	1.000912	.5099
232.529	65.26	1.001000	.5109
249.127	69.88	1.001071	.5110
269.103	75.44	1.001159	.5119
288.880	80.93	1.001245	.5126
310.844	87.02	1.001340	.5132
334.511	93.57	1.001443	.5139
322.044	90.12	1.001389	.5136
303.035	84.86	1.001308	.5137
284.162	79.62	1.001226	.5131
262.113	73.50	1.001131	.5127
241.567	67.78	1.001042	.5126
49.740	14.04	1.000192	.4564
20.284	5.73	1.000060	.3494
80.922	22.82	1.000329	.4811
114.379	32.23	1.000478	.4951
977.900	26.78	1.004157	.5166
112.977	31.83	1.000616	.6449
113.188	31.89	1.000616	.6437
19.465	5.50	1.000057	.3458
19.465	5.50	1.000055	.3337
182.740	51.37	1.000796	.5165
512.055	142.40	1.002215	.5181
76.703	21.64	1.000413	.6371
65.523	18.49	1.000349	.6300
31.388	8.86	1.000152	.5722
31.450	8.88	1.000153	.5748
244.236	68.52	1.001038	.5051
827.037	227.64	1.003523	.5153
694.389	191.96	1.002969	.5151

Frequency* (hertz)	Density, $\rho \times 10^3$ (moles/cm^3)	Dielectric constant	CM^3 (cm^3)
	Composition 100% He		
0.2096	1.0000572	1.0000572	15000.0
5184.	2.0000572	1.0000572	15000.0
6164.	3.0000572	1.0000572	15000.0
7202.	4.0000572	1.0000572	15000.0
8002.	5.0000572	1.0000572	15000.0
9012.	6.0000572	1.0000572	15000.0
0112.	7.0000572	1.0000572	15000.0
1012.	8.0000572	1.0000572	15000.0
2012.	9.0000572	1.0000572	15000.0
3012.	10.000057	1.0000572	15000.0
4012.	11.000057	1.0000572	15000.0
5012.	12.000057	1.0000572	15000.0
6012.	13.000057	1.0000572	15000.0
7012.	14.000057	1.0000572	15000.0
8012.	15.000057	1.0000572	15000.0
9012.	16.000057	1.0000572	15000.0
0012.	17.000057	1.0000572	15000.0
1012.	18.000057	1.0000572	15000.0
2012.	19.000057	1.0000572	15000.0
3012.	20.000057	1.0000572	15000.0
4012.	21.000057	1.0000572	15000.0
5012.	22.000057	1.0000572	15000.0
6012.	23.000057	1.0000572	15000.0
7012.	24.000057	1.0000572	15000.0
8012.	25.000057	1.0000572	15000.0
9012.	26.000057	1.0000572	15000.0
0112.	27.000057	1.0000572	15000.0
1012.	28.000057	1.0000572	15000.0
2012.	29.000057	1.0000572	15000.0
3012.	30.000057	1.0000572	15000.0
4012.	31.000057	1.0000572	15000.0
5012.	32.000057	1.0000572	15000.0
6012.	33.000057	1.0000572	15000.0
7012.	34.000057	1.0000572	15000.0
8012.	35.000057	1.0000572	15000.0
9012.	36.000057	1.0000572	15000.0
0112.	37.000057	1.0000572	15000.0
1012.	38.000057	1.0000572	15000.0
2012.	39.000057	1.0000572	15000.0
3012.	40.000057	1.0000572	15000.0
4012.	41.000057	1.0000572	15000.0
5012.	42.000057	1.0000572	15000.0
6012.	43.000057	1.0000572	15000.0
7012.	44.000057	1.0000572	15000.0
8012.	45.000057	1.0000572	15000.0
9012.	46.000057	1.0000572	15000.0
0112.	47.000057	1.0000572	15000.0
1012.	48.000057	1.0000572	15000.0
2012.	49.000057	1.0000572	15000.0
3012.	50.000057	1.0000572	15000.0
4012.	51.000057	1.0000572	15000.0
5012.	52.000057	1.0000572	15000.0
6012.	53.000057	1.0000572	15000.0
7012.	54.000057	1.0000572	15000.0
8012.	55.000057	1.0000572	15000.0
9012.	56.000057	1.0000572	15000.0
0112.	57.000057	1.0000572	15000.0
1012.	58.000057	1.0000572	15000.0
2012.	59.000057	1.0000572	15000.0
3012.	60.000057	1.0000572	15000.0
4012.	61.000057	1.0000572	15000.0
5012.	62.000057	1.0000572	15000.0
6012.	63.000057	1.0000572	15000.0
7012.	64.000057	1.0000572	15000.0
8012.	65.000057	1.0000572	15000.0
9012.	66.000057	1.0000572	15000.0
0112.	67.000057	1.0000572	15000.0
1012.	68.000057	1.0000572	15000.0
2012.	69.000057	1.0000572	15000.0
3012.	70.000057	1.0000572	15000.0
4012.	71.000057	1.0000572	15000.0
5012.	72.000057	1.0000572	15000.0
6012.	73.000057	1.0000572	15000.0
7012.	74.000057	1.0000572	15000.0
8012.	75.000057	1.0000572	15000.0
9012.	76.000057	1.0000572	15000.0
0112.	77.000057	1.0000572	15000.0
1012.	78.000057	1.0000572	15000.0
2012.	79.000057	1.0000572	15000.0
3012.	80.000057	1.0000572	15000.0
4012.	81.000057	1.0000572	15000.0
5012.	82.000057	1.0000572	15000.0
6012.	83.000057	1.0000572	15000.0
7012.	84.000057	1.0000572	15000.0
8012.	85.000057	1.0000572	15000.0
9012.	86.000057	1.0000572	15000.0
0112.	87.000057	1.0000572	15000.0
1012.	88.000057	1.0000572	15000.0
2012.	89.000057	1.0000572	15000.0
3012.	90.000057	1.0000572	15000.0
4012.	91.000057	1.0000572	15000.0
5012.	92.000057	1.0000572	15000.0
6012.	93.000057	1.0000572	15000.0
7012.	94.000057	1.0000572	15000.0
8012.	95.000057	1.0000572	15000.0
9012.	96.000057	1.0000572	15000.0
0112.	97.000057	1.0000572	15000.0
1012.	98.000057	1.0000572	15000.0
2012.	99.000057	1.0000572	15000.0
3012.	100.00005	1.0000572	15000.0
4012.	101.00005	1.0000572	15000.0
5012.	102.00005	1.0000572	15000.0
6012.	103.00005	1.0000572	15000.0
7012.	104.00005	1.0000572	15000.0
8012.	105.00005	1.0000572	15000.0
9012.	106.00005	1.0000572	15000.0
0112.	107.00005	1.0000572	15000.0
1012.	108.00005	1.0000572	15000.0
2012.	109.00005	1.0000572	15000.0
3012.	110.00005	1.0000572	15000.0
4012.	111.00005	1.0000572	15000.0
5012.	112.00005	1.0000572	15000.0
6012.	113.00005	1.0000572	15000.0
7012.	114.00005	1.0000572	15000.0
8012.	115.00005	1.0000572	15000.0
9012.	116.00005	1.0000572	15000.0
0112.	117.00005	1.0000572	15000.0
1012.	118.00005	1.0000572	15000.0
2012.	119.00005	1.0000572	15000.0
3012.	120.00005	1.0000572	15000.0
4012.	121.00005	1.0000572	15000.0
5012.	122.00005	1.0000572	15000.0
6012.	123.00005	1.0000572	15000.0
7012.	124.00005	1.0000572	15000.0
8012.	125.00005	1.0000572	15000.0
9012.	126.00005	1.0000572	15000.0
0112.	127.00005	1.0000572	15000.0
1012.	128.00005	1.0000572	15000.0
2012.	129.00005	1.0000572	15000.0
3012.	130.00005	1.0000572	15000.0
4012.	131.00005	1.0000572	15000.0
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7012.	134.00005	1.0000572	15000.0
8012.	135.00005	1.0000572	15000.0
9012.	136.00005	1.0000572	15000.0
0112.	137.00005	1.0000572	15000.0
1012.	138.00005	1.0000572	15000.0
2012.	139.00005	1.0000572	15000.0
3012.	140.00005	1.0000572	15000.0
4012.	141.00005	1.0000572	15000.0
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8012.	145.00005	1.0000572	15000.0
9012.	146.00005	1.0000572	15000.0
0112.	147.00005	1.0000572	15000.0
1012.	148.00005	1.0000572	15000.0
2012.	149.00005	1.0000572	15000.0
3012.	150.00005	1.0000572	15000.0
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5012.	152.00005	1.0000572	15000.0
6012.	153.00005	1.0000572	15000.0
7012.	154.00005	1.0000572	15000.0
8012.	155.00005	1.0000572	15000.0
9012.	156.00005	1.0000572	15000.0
0112.	157.00005	1.0000572	15000.0
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2012.	159.00005	1.0000572	15000.0
3012.	160.00005	1.0000572	15000.0
4012.	161.00005	1.0000572	15000.0
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9012.	166.00005	1.0000572	15000.0
0112.	167.00005	1.0000572	15000.0
1012.	168.00005	1.0000572	15000.0
2012.	169.00005	1.0000572	15000.0
3012.	170.00005	1.0000572	15000.0
4012.	171.00005	1.0000572	15000.0
5012.	172.00005	1.0000572	15000.0
6012.	173.00005	1.0000572	15000.0
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0112.	177.00005	1.0000572	15000.0
1012.	178.00005	1.0000572	15000.0
2012.	179.00005	1.0000572	15000.0
3012.	180.00005	1.0000572	15000.0
4012.	181.00005	1.0000572	15000.0
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7012.	184.00005	1.0000572	15000.0
8012.	185.00005	1.0000572	15000.0
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2012.	189.00005	1.0000572	15000.0
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9012.	196.00005	1.0000572	15000.0
0112.	197.00005	1.0000572	15000.0
1012.	198.00005	1.0000572	15000.0
2012.	199.00005	1.0000572	15000.0
3012.	200.00005	1.0000572	15000.0
4012.	201.00005	1.0000572	15000.0
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0112.	207.00005	1.0000572	15000.0
1012.	208.00005	1.0000572	15000.0
2012.	209.00005	1.0000572	15000.0
3012.	210.00005	1.0000572	15000.0
4012.	211.00005	1.0000572	15000.0
5012.	212.00005	1.0000572	15000.0
6012.	213.00005	1.0000572	15000.0
7012.	214.00005	1.0000572	15000.0
8012.	215.00005	1.0000572	15000.0
9012.	216.00005	1.0000572	15000.0
0112.	217.00005	1.0000572	15000.0
1012.	218.00005	1.0000572	15000.0
2012.	219.00005	1.0000572	15000.0
3012.	220.00005	1.0000572	15000.0
4012.	221.00005	1.0000572	15000.0
5012.	222.00005	1.0000572	15000.0
6012.	223.00005	1.0000572	15000.0
7012.	224.00005	1.0000572	15000.0
8012.	225.00005	1.0000572	15000.0
9012.	226.00005	1.0000572	15000.0
0112.	227.00005	1.0000572	15000.0
1012.	228.00005	1.0000572	15000.0
2012.	229.00005	1.0000572	15000.0
3012.	230.00005	1.0000572	15000.0
4012.	231.00005	1.0000572	15000.0
5012.	232.00005	1.0000572	15000.0
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0112.	237.00005	1.0000572	15000.0
1012.	238.00005	1.0000572	15000.0
2012.	239.00005	1.0000572	15000.0
3012.	240.00005	1.0000572	15000.0
4012.	241.00005	1.0000572	15000.0
5012.	242.00005	1.0000572	15000.0
6012.	243.00005	1.0000572	15000.0
7012.	244.00005	1.0000572	15000.0
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2012.	249.00005	1.0000572	15000.0
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4012.	251.00005	1.0000572	15000.0
5012.	252.00005	1.0000572	15000.0
6012.	253.00005	1.0000572	15000.0
7012.	254.00005	1.0000572	15000.0
8012.	255.00005	1.0000572	15000.0
9012.	256.00005	1.0000572	15000.0
0112.	257.00005	1.0000572	15000.0
1012.	258.00005	1.0000572	15000.0
2012.	259.00005	1.0000572	15000.0
3012.	260.00005	1.0000572	15000.0
4012.	261.00005	1.0000572	15000.0
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9012.	266.00005	1.0000572	15000.0
0112.	267.00005	1.0000572	15000.0
1012.	268.00005	1.0000572	15000.0
2012.	269.00005	1.0000572	15000.0
3012.	270.00005	1.0000572	15000.0
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5012.	272.00005	1.0000572	15000.0
6012.	273.00005	1.0000572	15000.0
7012.	274.00005	1.0000572	15000.0
8012.	275.00005	1.0000572	15000.0
9012.	276.00005	1.0000572	15000.0
0112.	277.00005	1.0000572	15000.0
1012.	278.00005	1.0000572	15000.0
2012.	279.00005	1.0000572	15000.0
3012.	280.00005	1.0000572	15000.0
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9012.	286.00005	1.0000572	15000.0
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1012.	288.00005	1.0000572	15000.0
2012.	289.00005	1.0000572	15000.0
3012.	290.00005	1.0000572	15000.0
4012.	291.00005	1.0000572	15000.0
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9012.	296.00005	1.0000572	15000.0
0112.	297.00005	1.0000572	15000.0
1012.	298.00005	1.0000572	15000.0
2012.	299.00005	1.0000572	15000.0
3012.	300.00005	1.0000572	15000.0
4012.	301.00005	1.0000572	15000.0
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8012.	305.00005	1.0000572	15000.0
9012.	306.00005	1.0000572	15000.0
0112.	307.00005	1.0000572	15000.0
1012.	308.00005	1.0000572	15000.0
2012.	309.00005	1.0000572	15000.0
3012.	310.00005	1.0000572	15000.0
4012.	311.00005	1.0000572	15000.0
5012.	312.00005	1.0000572	15000.0
6012.	313.00005	1.0000572	15000.0
7012.	314.00005	1.0000572	15000.0
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9012.	316.00005	1.0000572	15000.0
0112.	317.00005	1.0000572	15000.0
1012.	318.00005	1.0000572	15000.0
2012.	319.00005	1.0000572	15000.0
3012.	320.00005	1.0000572	15000.0
4012.	321.00005	1.0000572	15000.0
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7012.	324.00005	1.0000572	15000.0
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9012.	326.00005	1.0000572	15000.0
0112.	327.00005	1.0000572	15000.0
1012.	328.00005	1.0000572	15000.0
2012.	329.00005	1.0000572	15000.0
3012.	330.00005	1.0000572	15000.0
4012.	331.00005	1.0000572	15000.0
5012.	332.00005	1.0000572	15000.0
6012.	333.00005	1.0000572	15000.0
7012.	334.00005	1.0000572	15000.0
8012.	335.00005	1.0000572	15000.0
9012.	336.00005	1.0000572	15000.0
0112.	337.00005	1.0000572	15000.0
1012.	338.00005	1.0000572	15000.0
2012.	339.00005	1.0000572	15000.0
3012.	340.00005	1.0000572	15000.0
4012.	341.00005	1.0000572	15000.0
5012.	342.00005	1.0000572	15000.0
6012.	343.00005	1.0000572	15000.0
7012.	344.00005	1.0000572	15000.0
8012.	345.00005	1.0000572	15000.0
9012.	346.00005	1.0000572	15000.0
0112.	347.00005	1.0000572	15000.0
1012.	348.00005	1.0000572	15000.0
2012.	349.00005	1.0000572	15000.0
3012.	350.00005	1.0000572	15000.0
4012.	351.00005	1.0000572	15000.0
5012.	352.00005	1.0000572	15000.0
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7012.	354.00005	1.0000572	15000.0
8012.	355.00005	1.0000572	15000.0
9012.	356.00005	1.0000572	15000.0
0112.	357.00005	1.0000572	15000.0
1012.	358.00005	1.0000572	15000.0
2012.	359.00005	1.0000572	15000.0
3012.	360.00005	1.0000572	15000.0
4012.	361.00005	1.0000572	15000.0
5012.	362.00005	1.0000572	15000.0
6012.	363.00005	1.0000572	15000.0
7012.	364.00005	1.0000572	15000.0
8012.	365.00005	1.0000572	15000.0
9012.	366.00005	1.0000572	15000.0
0112.	367.00005	1.0000572	15000.0
1012.	368.00005	1.0000572	15000.0
2012.	369.00005	1.0000572	15000.0
3012.	370.00005	1.0000572	15000.0
4012.	371.00005	1.0000572	15000.0
5012.	372.00005	1.0000572	15000.0
6012.	373.00005	1.0000572	15000.0
7012.	374.00005	1.0000572	15000.0
8012.	375.00005	1.0000572	15000.0
9012.	376.00005	1.0000572	15000.0
0112.	377.00005	1.0000572	15000.0
1012.	378.00005	1.0000572	15000.0
2012.	379.00005	1.0000572	15000.0
3012.	380.00005	1.0000572	15000.0
4012.	381.00005	1.0000572	15000.0
5012.	382.00005	1.0000572	15000.0
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7012.	384.00005	1.0000572	15000.0
8012.	385.00005	1.0000572	15000.0
9012.	386.00005	1.0000572	15000.0
0112.	387.00005	1.0000572	15000.0
1012.	388.00005	1.0000572	15000.0
2012.	389.00005	1.0000572	15000.0
3012.	390.00005	1.0000572	15000.0
4012.	391.00005	1.0000572	15000.0
5012.	392.00005	1.0000572	15000.0
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8012.	395.00005	1.0000572	15000.0
9012.	396.00005	1.0000572	15000.0
0112.	397.00005	1.0000572	15000.0
1012.	398.00005	1.0000572	15000.0
2012.	399.00005	1.0000572	15000.0
3012.	400.00005	1.0000572	15000.0
4012.	401.00005	1.0000572	15000.0
5012.	402.00005	1.0000572	15000.0
6012.	403.00005	1.0000572	15000.0
7012.	404.00005	1.0000572	15000.0
8012.	405.00005	1.0000572	15000.0
9012.	406.00005	1.0000572	15000.0
0112.	407.00005	1.0000572	15000.0
1012.	408.00005	1.0000572	15000.0
2012.	409.00005	1.0000572	15000.0
3012.	410.00005	1.0000572	15000.0
4012.	411.00005	1.0000572	15000.0
5012.	412.00005	1.0000572	15000.0
6012.	413.00005	1.0000572	15000.0
7012.	414.00005	1.0000572	15000.0
8012.	415.00005	1.0000572	15000.0
9012.	416.00005	1.0000572	15000.0
0112.	417.00005	1.0000572	15000.0
1012.	418.00005	1.0000572	15000.0
2012.	419.00005	1.0000572	15000.0
3012.	420.00005	1.0000572	15000.0
4012.	421.00005	1.0000572	15000.0
5012.	422.00005	1.0000572	15000.0
6012.	423.00005	1.0000572	15000.0
7012.	424.00005	1.0000572	15000.0
8012.	425.00005	1.0000572	15000.0
9012.	426.00005	1.0000572	15000.0
0112.	427.00005	1.0000572	15000.0
1012.	428.00005	1.0000572	15000.0
2012.	429.00005	1.0000572	15000.0
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7012.	434.00005	1.0000572	15000.0
8012.	435.00005	1.0000572	15000.0
9012.	436.00005	1.0000572	15000.0
0112.	437.00005	1.0000572	15000.0
1012.	438.00005	1.0000572	15000.0
2012.	439.00005	1.0000572	15000.0
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5012.	442.00005	1.0000572	15000.0
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7012.	444.00005	1.0000572	15000.0
8012.	445.00005	1.0000572	15000.0
9012.	446.00005	1.0000572	15000.0
0112.	447.00005	1.0000572	15000.0
1012.	448.00005	1.0000572	15000.0
2012.	449.00005	1.0000572	15000.0
3012.	450.00005	1.0000572	15000.0
4012.	451.00005	1.0000572	15000.0
5012.	452.00005	1.0000572	15000.0
6012.	453.00005	1.0000572	15000.0
7012.	454.00005	1.0000572	15000.0
8012.	455.00005	1.0000572	15000.0
9012.	456.00005	1.0000572	15000.0
0112.	457.00005	1.0000572	15000.0
1012.	458.00005	1.0000572	15000.0
2012.	459.00005	1.0000572	15000.0
3012.	460.00005	1.0000572	15000.0
4012.	461.00005	1.0000572	15000.0
5012.	462.00005	1.0000572	15000.0
6012.	463.00005	1.0000572	15000.0
7012.	464.00005	1.0000572	15000.0
8012.	465.00005	1.0000572	15000.0
9012.	466.00005	1.0000572	15000.0
0112.	467.00005	1.0000572	15000.0
1012.	468.00005	1.0000572	15000.0
2012.	469.00005	1.0000572	15000.0
3012.	470.00005	1.0000572	15000.0
4012.	471.00005	1.0000572	15000.0
5012.	472.00005	1.0000572	15000.0
6012.	473.00005	1.0000572	15000.0
7012.	474.00005	1.0000572	15000.0
8012.	475.00005	1.0000572	15000.0
9012.	476.00005	1.0000572	15000.0
0112.	477.00005	1.0000572	15000.0
1012.	478.00005	1.0000572	15000.0
2012.	479.00005	1.0000572	15000.0
3012.	480.00005	1.0000572	15000.0
4012.	481.00005	1.0000572	15000.0
5012.	482.00005	1.0000572	15000.0
6012.	483.00005	1.0000572	15000.0
7012.	484.00005	1.0000572	15000.0
8012.	485.00005	1.0000572	15000.0
9012.	486.00005	1.0000572	15000.0
0112.	487.00005	1.0000572	15000.0
1012.	488.00005	1.0000572	15000.0
2012.	489.00005	1.0000572	15000.0
3012.	490.00005	1.0000572	15000.0
4012.	491.00005	1.0000572	15000.0
5012.	492.00005	1.0000572	15000.0
6012.	493.00005	1.0000572	15000.0
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8012.	495.00005	1.0000572	15000.0
9012.	496.00005	1.0000572	15000.0
0112.	497.00005	1.0000572	15000.0
1012.	498.00005	1.0000572	15000.0
2012.	499.00005	1.0000572	15000.0
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5012.	502.00005	1.0000572	15000.0
6012.	503.00005	1.0000572	15000.0
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2012.	509.00005	1.0000572	15000.0
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4012.	511.00005	1.0000572	15000.0
5012.	512.00005	1.0000572	15000.0
6012.	513.00005	1.0000572	15000.0
7012.	514.00005	1.0000572	15000.0
8012.	515.00005	1.0000572	15000.0
9012.	516.00005	1.0000572	15000.0
0112.	517.00005	1.0000572	15000.0
1012.	518.00005	1.0000572	15000.0
2012.	519.00005	1.0000572	15000.0
3012.	520.00005	1.0000572	15000.0
4012.	521.00005	1.0000572	15000.0
5012.	522.00005	1.0000572	15000.0
6012.	523.00005	1.0000572	15000.0
7012.	524.00005	1.0000572	15000.0
8012.	525.00005	1.0000572	15000.0
9012.	526.00005	1.0000572	15000.0
0112.	527.00005	1.0000572	15000.0
1012.	528.00005	1.0000572	15000.0
2012.	529.00005	1.0000572	15000.0
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6012.	533.00005	1.0000572	15000.0
7012.	534.00005	1.0000572	15000.0
8012.	535.00005	1.0000572	15000.0
9012.	536.00005	1.0000572	15000.0
0112.	537.00005	1.0000572	15000.0
1012.	538.00005	1.0000572	15000.0
2012.	539.00005	1.0000572	15000.0
3012.	540.00005	1.0000572	15000.0
4012.	541.00005	1.0000572	15000.0
5012.	542.00005	1.0000572	15000.0
6012.	543.00005	1.0000572	15000.0
7012.	544.00005	1.0000572	15000.0
8012.	545.00005	1.0000572	15000.0
9012.	546.00005	1.0000572	15000.0
0112.	547.00005	1.0000572	15000.0
1012.	548.00005	1.0000572	15000.0
2012.	549.00

TABLE 1.- Dielectric constants for $He-CO_2$ system at 20° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM_3, (cm^3)
	Composition 100% He		
565.687	157.04	1.002429	0.5152
403.457	112.60	1.001735	.5133
122.371	34.47	1.000557	.5384
122.595	34.53	1.000561	.5413
46.712	13.19	1.000205	.5188
18.807	5.31	1.000076	.4773
18.882	5.33	1.000076	.4754
104.029	29.32	1.000489	.5567
247.637	69.47	1.001120	.5371
312.955	87.61	1.001404	.5341
332.959	93.14	1.001492	.5339
265.775	75.51	1.001191	.5326
224.982	63.16	1.001007	.5316
185.905	52.26	1.000831	.5301
129.433	36.45	1.000575	.5256
82.896	23.38	1.000448	.6396
57.482	16.22	1.000306	.6295
19.576	5.53	1.000092	.5551
791.928	218.23	1.003427	.5228
187.805	52.79	1.000832	.5254
62.495	17.64	1.000273	.5167
19.701	5.56	1.000067	.4017
34.738	9.81	1.000152	.5171
1004.853	274.99	1.004283	.5185
809.756	223.01	1.003472	.5183
686.547	189.84	1.002955	.5184
537.833	149.44	1.002322	.5175
438.668	122.29	1.001896	.5165
111.934	31.54	1.000473	.5006
212.395	59.65	1.000910	.5086
233.287	65.48	1.001000	.5093
253.559	71.12	1.001088	.5101
272.542	76.39	1.001171	.5107
292.965	82.06	1.001259	.5112

Pressure (bars)	Density $\times 10^2$ (moles/cm^3)	Dielectric constant	CH_4 (cm^3)
	Composition 100% He		
0.5125	1.005456		
	1.001732		
	1.000252		
	1.000182		
	1.000126		
	1.000076		
	1.000050		
	1.000034		
	1.000019		
	1.000013		
	1.000009		
	1.000006		
	1.000004		
	1.000003		
	1.000002		
	1.000001		
	1.000001		
	1.000000		
	1.000000		

TABLE I.- Dielectric constants for $He-CO_2$ system at 30° C (Cont.)

TABLE 1.- Dielectric constants for $He-CO_2$ system at 20° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM_1 (cm^3)
	Composition 100% He		
313.526	87.76	1.001348	0.5119
333.840	93.39	1.001436	.5125
350.989	98.13	1.001509	.5125
368.399	102.94	1.001585	.5132
387.412	108.18	1.001668	.5136
410.809	114.63	1.001769	.5141
403.246	112.54	1.001737	.5141
407.319	113.67	1.001782	.5223
428.893	119.60	1.001877	.5228
446.728	124.50	1.001952	.5224
466.863	130.03	1.002037	.5220
491.247	136.71	1.002141	.5218
515.806	143.43	1.002246	.5215
533.981	148.39	1.002323	.5214
549.138	152.53	1.002388	.5215
574.087	159.33	1.002494	.5214
594.961	165.01	1.002582	.5212
612.444	169.76	1.002656	.5212
602.789	167.14	1.002614	.5210
583.902	162.00	1.002534	.5210
563.749	156.51	1.002448	.5210
541.274	150.38	1.002352	.5209
519.956	144.56	1.002261	.5209
504.725	140.40	1.002196	.5209
392.180	109.50	1.001735	.5279
359.743	100.55	1.001592	.5277
334.995	93.71	1.001483	.5275
299.446	83.86	1.001327	.5273
267.973	75.12	1.001191	.5282
238.898	67.04	1.001062	.5283
209.962	58.97	1.000935	.5286
178.458	50.18	1.000795	.5282
147.441	41.50	1.000657	.5277
120.199	33.86	1.000534	.5264
89.249	25.17	1.000395	.5239

Frequency (hz)	Density (moles/cm^3) x 10^2	Dielectric constant	(cm_3) CM^4
	Combustion 1002 HC		
0.2115	18.35	1.0013458	215.252
	13.39	1.0013436	333.840
	69.13	1.0012905	350.864
	101.44	1.0012582	348.336
	81.80	1.0012888	314.786
	114.63	1.0012964	410.804
	111.24	1.0012631	403.548
	111.14	1.0012585	404.314
	114.11	1.0012611	408.458
	112.42	1.0012600	404.258

TABLE I.- Dielectric constants (or H_2-CO_2 system at 30° C (Cont'd)

TABLE 1.- Dielectric constants for $He-CO_2$ system at 20° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM_3, (cm^3)
	Composition 100% He		
30.073	8.49	1.000127	0.4990
56.068	15.83	1.000251	.5294
107.367	30.26	1.000474	.5229
153.163	43.10	1.000673	.5205
196.171	55.13	1.000859	.5195
808.090	222.56	1.003458	.5173
711.864	196.68	1.003057	.5176
610.679	169.28	1.002632	.5179
501.880	139.62	1.002173	.5183
402.712	112.40	1.001749	.5184
300.961	84.28	1.001313	.5192
114.962	32.39	1.000530	.5461
209.999	58.98	1.000958	.5415
999.306	273.52	1.004313	.5248
928.352	254.69	1.004018	.5252
807.655	222.45	1.003513	.5259
703.313	194.37	1.003073	.5264
448.939	125.11	1.001991	.5301
400.613	111.82	1.001787	.5323
298.230	83.52	1.001334	.5322
242.051	67.92	1.001087	.5336
143.470	40.39	1.000650	.5363
360.128	100.65	1.001658	.5490
496.402	138.12	1.002256	.5442
607.784	168.49	1.002734	.5404
761.360	210.01	1.003386	.5369
859.065	236.21	1.003795	.5349

Pressure (bars)	Density (moles/cm^3) x 10^2	Dielectric constant	CM^2 (cm^3)
	Combustion Tool #4		

TABLE I.- Dielectric constant for Ne-CO_2 mixture at 30° C (CGS)

TABLE 1.- Dielectric constants for He-CO_2 system at 20° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM_3, (cm^3)
	Composition 94.72% He - 5.28% CO_2		
23.572	6.66	1.0001482	0.7417
41.166	11.62	1.0002765	.7925
56.576	15.97	1.0003877	.8089
74.110	20.91	1.0005520	.8798
95.913	27.04	1.0007203	.8876
118.350	33.34	1.0009106	.9101
171.805	48.31	1.0013504	.9313
219.942	61.74	1.0017061	.9205
204.214	57.36	1.0016870	.9798
267.576	74.99	1.0021579	.9584
57.197	16.14	1.0003937	.8126
57.098	16.11	1.0004227	.8741
57.197	16.14	1.0003987	.8229
57.085	16.11	1.0004017	.8307
125.300	35.29	1.0009056	.8551
163.390	45.95	1.0012192	.8839
209.341	58.78	1.0015558	.8816
262.920	73.69	1.0019425	.8779
303.556	84.97	1.0022601	.8859
340.546	95.20	1.0025306	.8852
374.136	104.47	1.0027730	.8839
403.358	112.52	1.0029834	.8829
424.409	118.30	1.0031537	.8876
452.094	125.90	1.0033551	.8872
475.657	132.36	1.0035254	.8867
510.750	141.95	1.0037789	.8862
475.558	132.33	1.0035795	.9005
546.480	151.69	1.0040935	.8982
592.488	164.21	1.0044211	.8961
645.436	178.56	1.0047967	.8939
667.880	184.63	1.0049550	.8930
682.060	188.46	1.0050502	.8917
673.100	186.04	1.0049841	.8915
596.054	165.18	1.0044271	.8920
495.930	137.90	1.0037138	.8965
485.023	134.92	1.0036326	.8963
445.934	124.21	1.0033291	.8923
374.918	104.68	1.0028021	.8913

TABLE I.- Dissociation constants for H_2O-CO_2 system at 30° C (Cohn)

Parameter (beta)	Found (molar CO_2) * 10^2	Difference	cm^{-1}
	Combination 46.152 H$_2$O - 2.582 CO$_2$		

TABLE 1.- Dielectric constants for $He-CO_2$ system at 20° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM_3, (cm^3)
	Composition 94.72% He - 5.28% CO_2		
725.039	200.04	1.0052876	0.8795
337.590	94.38	1.0025146	.8872
370.137	103.37	1.0027530	.8869
301.383	84.36	1.0022441	.8859
258.823	72.56	1.0019285	.8853
192.186	54.00	1.0014286	.8813
117.407	33.07	1.0009146	.9214
86.631	24.43	1.0006702	.9141
59.083	16.67	1.0004518	.9028
41.736	11.78	1.0003115	.8808
25.656	7.25	1.0001863	.8565
16.388	4.63	1.0000891	.6414
24.998	7.06	1.0001552	.7325
37.480	10.58	1.0002494	.7852
51.377	14.50	1.0003917	.8998
78.875	22.25	1.0005960	.8927
91.446	25.78	1.0006882	.8894
81.320	22.93	1.0006091	.8849
68.712	19.39	1.0005099	.8764
56.006	15.81	1.0004117	.8678
43.536	12.29	1.0003135	.8499
31.078	8.78	1.0002153	.8174
29.465	8.32	1.0002434	.9744
	Composition 93.6% He - 6.4% CO_2		
37.952	10.72	1.0002644	.8221
83.317	23.50	1.0006642	.9419
114.528	32.26	1.0009186	.9486
147.975	41.64	1.0011901	.9522
188.227	52.89	1.0015157	.9546
211.277	59.32	1.0017001	.9546
245.887	68.96	1.0019806	.9566
293.785	82.26	1.0023643	.9572
365.071	101.97	1.0029333	.9578
394.428	110.06	1.0031868	.9641
62.967	17.77	1.0004788	.8979
157.743	44.37	1.0012422	.9326

Pressure (bars)	Density (moles/cm^3) x 10^2	Diffusivity (cm^2/sec)
Combustion 35.2 kW - 0.24 CO_2		
1.0	4.0	1.0000E-01
2.0	8.0	5.0000E-02
3.0	12.0	3.3333E-02
4.0	16.0	2.5000E-02
5.0	20.0	2.0000E-02
6.0	24.0	1.6667E-02
7.0	28.0	1.4286E-02
8.0	32.0	1.2500E-02
9.0	36.0	1.1111E-02
10.0	40.0	1.0000E-02
11.0	44.0	9.0909E-03
12.0	48.0	8.3333E-03
13.0	52.0	7.6923E-03
14.0	56.0	7.1429E-03
15.0	60.0	6.6667E-03
16.0	64.0	6.2500E-03
17.0	68.0	5.8824E-03
18.0	72.0	5.5556E-03
19.0	76.0	5.2632E-03
20.0	80.0	5.0000E-03
Combustion 35.2 kW - 0.24 CO_2		
1.0	4.0	1.0000E-01
2.0	8.0	5.0000E-02
3.0	12.0	3.3333E-02
4.0	16.0	2.5000E-02
5.0	20.0	2.0000E-02
6.0	24.0	1.6667E-02
7.0	28.0	1.4286E-02
8.0	32.0	1.2500E-02
9.0	36.0	1.1111E-02
10.0	40.0	1.0000E-02
11.0	44.0	9.0909E-03
12.0	48.0	8.3333E-03
13.0	52.0	7.6923E-03
14.0	56.0	7.1429E-03
15.0	60.0	6.6667E-03
16.0	64.0	6.2500E-03
17.0	68.0	5.8824E-03
18.0	72.0	5.5556E-03
19.0	76.0	5.2632E-03
20.0	80.0	5.0000E-03
Combustion 35.2 kW - 0.24 CO_2		
1.0	4.0	1.0000E-01
2.0	8.0	5.0000E-02
3.0	12.0	3.3333E-02
4.0	16.0	2.5000E-02
5.0	20.0	2.0000E-02
6.0	24.0	1.6667E-02
7.0	28.0	1.4286E-02
8.0	32.0	1.2500E-02
9.0	36.0	1.1111E-02
10.0	40.0	1.0000E-02
11.0	44.0	9.0909E-03
12.0	48.0	8.3333E-03
13.0	52.0	7.6923E-03
14.0	56.0	7.1429E-03
15.0	60.0	6.6667E-03
16.0	64.0	6.2500E-03
17.0	68.0	5.8824E-03
18.0	72.0	5.5556E-03
19.0	76.0	5.2632E-03
20.0	80.0	5.0000E-03

TABLE I.- Diffusivity coefficient coefficients for H_2-CO_2 mixtures at CO_2 C (COM')

TABLE 1.- Dielectric constants for He-CO_2 system at 20° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM_3, (cm^3)
	Composition 93.6% He - 6.4% CO_2		
256.042	71.78	1.0020297	0.9417
311.291	87.11	1.0024685	.9437
411.232	114.68	1.0032619	.9470
425.440	118.59	1.0033741	.9473
373.739	104.36	1.0029654	.9461
333.145	93.15	1.0026428	.9447
288.396	80.77	1.0022862	.9427
229.662	64.45	1.0018193	.9403
182.529	51.30	1.0014676	.9530
133.218	37.51	1.0010659	.9468
95.404	26.89	1.0007543	.9345
52.978	14.95	1.0004027	.8972
17.926	5.06	1.0001122	.7379
6.016	1.70	1.0000100	.1962
113.163	31.88	1.0009305	.9724
210.843	59.20	1.0017169	.9660
301.830	84.49	1.0024431	.9630
250.232	70.17	1.0020354	.9661
146.299	41.17	1.0012020	.9726
353.522	98.78	1.0028808	.9711
301.880	84.50	1.0024691	.9731
331.841	92.79	1.0027085	.9720
285.764	80.04	1.0023429	.9749
224.150	62.91	1.0018471	.9779
181.003	50.88	1.0014964	.9798
122.272	34.44	1.0010207	.9875
76.021	21.44	1.0006440	1.0007
17.517	4.95	1.0001672	1.1258
11.524	3.25	1.0001172	1.1987
	Composition 89.13% He - 10.87% CO_2		
42.047	11.87	1.0005369	1.5066
60.522	17.08	1.0005830	1.1372
149.750	42.15	1.0015348	1.2129
214.728	60.32	1.0023573	1.3015
250.220	70.21	1.0027310	1.2953
348.505	97.47	1.0037549	1.2824

Pressure (bars)	Density (moles/cm^3) x 10^2	Constant	CM^2 (cm^2)
Composition 99.75% H_2 - 0.25% CO_2			
0.0971	4.17	1.0000	240.025
0.1961	8.41	1.0000	238.11
0.2941	12.61	1.0000	233.11
0.3922	16.81	1.0000	233.11
0.4902	21.01	1.0000	233.11
0.5882	25.21	1.0000	233.11
0.6863	29.41	1.0000	233.11
0.7843	33.61	1.0000	233.11
0.8824	37.81	1.0000	233.11
0.9804	42.01	1.0000	233.11
Composition 97.75% H_2 - 2.25% CO_2			
0.0971	4.17	1.0000	240.025
0.1961	8.41	1.0000	238.11
0.2941	12.61	1.0000	233.11
0.3922	16.81	1.0000	233.11
0.4902	21.01	1.0000	233.11
0.5882	25.21	1.0000	233.11
0.6863	29.41	1.0000	233.11
0.7843	33.61	1.0000	233.11
0.8824	37.81	1.0000	233.11
0.9804	42.01	1.0000	233.11
Composition 95.25% H_2 - 4.75% CO_2			
0.0971	4.17	1.0000	240.025
0.1961	8.41	1.0000	238.11
0.2941	12.61	1.0000	233.11
0.3922	16.81	1.0000	233.11
0.4902	21.01	1.0000	233.11
0.5882	25.21	1.0000	233.11
0.6863	29.41	1.0000	233.11
0.7843	33.61	1.0000	233.11
0.8824	37.81	1.0000	233.11
0.9804	42.01	1.0000	233.11
Composition 90.25% H_2 - 9.75% CO_2			
0.0971	4.17	1.0000	240.025
0.1961	8.41	1.0000	238.11
0.2941	12.61	1.0000	233.11
0.3922	16.81	1.0000	233.11
0.4902	21.01	1.0000	233.11
0.5882	25.21	1.0000	233.11
0.6863	29.41	1.0000	233.11
0.7843	33.61	1.0000	233.11
0.8824	37.81	1.0000	233.11
0.9804	42.01	1.0000	233.11

TABLE I.- Diffusivity coefficients for H_2-CO_2 system at 50° C (Cont.)

TABLE 1.- Dielectric constants for $He-CO_2$ system at 20° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM_3, (cm^3)
	Composition 89.13% He - 10.87% CO_2		
417.628	116.54	1.0044862	1.2811
473.745	131.96	1.0050733	1.2793
473.620	131.92	1.0050843	1.2824
473.633	131.92	1.0050823	1.2819
438.444	122.27	1.0047026	1.2800
142.700	40.18	1.0015949	1.3223
15.507	4.38	1.0001372	1.0433
153.200	43.12	1.0015839	1.2236
208.149	58.48	1.0021870	1.2455
274.156	76.86	1.0028853	1.2499
331.195	92.68	1.0034864	1.2523
376.247	105.14	1.0039573	1.2529
417.280	116.44	1.0043891	1.2545
454.293	126.62	1.0047738	1.2546
480.924	133.92	1.0050513	1.2551
522.900	145.41	1.0054911	1.2564
563.401	156.46	1.0059309	1.2610
596.675	165.52	1.0062735	1.2607
646.244	178.97	1.0067824	1.2603
593.246	164.59	1.0062525	1.2636
702.157	194.10	1.0073745	1.2633
721.982	199.44	1.0075789	1.2634
670.726	185.60	1.0070479	1.2627
555.823	154.40	1.0058547	1.2614
498.005	138.60	1.0052526	1.2609
425.986	118.84	1.0044983	1.2597
333.902	93.43	1.0035325	1.2587
309.516	86.68	1.0032760	1.2584
261.964	73.47	1.0029093	1.3185
50.385	14.22	1.0005470	1.2811
28.746	8.12	1.0002985	1.2248
18.063	5.10	1.0002093	1.3665
17.641	4.98	1.0001693	1.1314
98.482	27.77	1.0010318	1.2381

Frequency (hertz)	Damping (cm^2 sec) x 10^2	Dielectric constant	(cm^{-1})
Combination 88.132 Hg - 10.812 CO^3			

TABLE I.- Dielectric constant for $Hg-CO^3$ system at 30° C (CO^{-1})

TABLE 1.- Dielectric constants for He-CO_2 system at 20° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM_3, (cm^3)
	Composition 75.1% He - 24.7% CO_2		
89.832	25.37	1.0016910	2.2201
217.074	61.18	1.0041475	2.2565
298.825	84.09	1.0057194	2.2626
439.127	123.25	1.0084163	2.2698
567.874	158.96	1.0108848	2.2742
686.522	191.67	1.0131559	2.2778
779.236	217.10	1.0149241	2.2800
637.657	178.22	1.0122362	2.2791
515.173	144.37	1.0099220	2.2833
425.055	119.33	1.0081879	2.2808
	Composition 48.7% He - 50.9% CO_2		
38.163	10.82	1.0012472	3.8406
71.641	20.35	1.0024314	3.9786
160.957	45.97	1.0055431	4.0116
317.636	91.55	1.0111223	4.0345
689.418	202.78	1.0247441	4.0342
823.133	243.77	1.0298615	4.0430
823.605	243.91	1.0298645	4.0410
575.950	168.39	1.0204583	4.0222
481.744	140.13	1.0169679	4.0134
379.290	109.70	1.0132452	4.0068
227.986	65.37	1.0078002	3.9669
105.866	30.13	1.0035014	3.8679
11.090	3.13	1.0004388	4.6583
27.343	7.74	1.0009888	4.2527
51.762	14.68	1.0018263	4.1420
66.528	18.89	1.0023413	4.1270
89.609	25.48	1.0031407	4.1034
109.949	31.30	1.0038540	4.0979
211.166	60.49	1.0074086	4.0723
307.355	88.53	1.0104381	3.9162
410.126	118.82	1.0145506	4.0619
509.334	148.38	1.0181853	4.0606
603.907	176.83	1.0215654	4.0361
708.521	208.60	1.0254866	4.0382
797.212	235.78	1.0288538	4.0402

Fraction, (basis)	Density, $(moles/cm^3) \times 10^2$	Diffusivity constant	CH^3, (cm^2)
Composition 12.1% Ne - 24.7% CO_2			
1055.5	1.0018910	0198100.1	52.75
2582.5	1.0021420	2142400.1	18.12
4520.5	1.0021750	1271500.1	84.04
6540.5	1.0021840	1384800.1	45.84
8085.5	1.0021880	0188800.1	45.74
8115.5	1.0022510	2251300.1	88.74
8080.5	1.0021940	1269400.1	02.74
7615.5	1.0022510	3652510.1	55.81
5385.5	1.0022600	0552600.1	44.71
3085.5	1.0021800	6218800.1	11.84
Composition 12.1% Ne - 24.7% CO_2			
1110.4	1.0022500	1643500.1	50.61
2420.4	1.0022110	5551110.1	16.72
3420.4	1.0021420	1441420.1	20.58
4540.4	1.0021420	2138620.1	22.43	77.58
6040.4	1.0021420	2388620.1	19.43	20.58
7140.4	1.0021420	2482020.1	88.81	25.52
8000.4	1.0021420	2525210.1	01.601	07.612
8610.4	1.0021420	6136910.1	13.041	44.184
9000.4	1.0021420	2525210.1	01.601	07.612
9300.4	1.0021420	5008100.1	12.58	98.122
9515.4	1.0021420	2102500.1	13.06	98.201
9680.4	1.0021420	8864000.1	13.3	06.11
9752.4	1.0021420	8886000.1	14.1	13.21
9820.4	1.0021420	6852100.1	89.41	29.12
9870.4	1.0021420	6152500.1	98.81	85.39
9901.4	1.0021420	1041500.1	84.52	60.68
9940.4	1.0021420	0428600.1	02.12	46.901
9961.4	1.0021420	4804100.1	64.09	99.112
9980.4	1.0021420	1864010.1	23.88	22.106
9990.4	1.0021420	3022410.1	58.811	95.014
9998.4	1.0021420	6218810.1	86.84	46.905
9999.4	1.0021420	4582150.1	68.612	106.609
9999.4	1.0021420	8488520.1	09.805	152.801
9999.4	1.0021420	8628850.1	82.565	212.191

TABLE I.- Diffusivity constants for $He-CO_2$ system at 50° C (Con.)

TABLE 1.- Dielectric constants for $He-CO_2$ system at 20° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM_3, (cm^3)
	Composition 48.7% He - 50.9% CO_2		
757.904	223.71	1.0273701	4.0412
658.211	193.28	1.0236112	4.0401
603.249	176.63	1.0215564	4.0390
553.723	161.70	1.0197551	4.0456
454.256	131.93	1.0161025	4.0465
351.225	101.42	1.0123646	4.0469
248.159	71.24	1.0086879	4.0532
148.608	42.41	1.0051895	4.0713
123.736	35.26	1.0043269	4.0841
93.630	26.63	1.0032820	4.1027
67.211	19.09	1.0023683	4.1320
34.031	9.64	1.0012222	4.2216
11.053	3.12	1.0004327	4.6100
	Composition 24.7% He - 74.6% CO_2		
98.457	28.36	1.0045713	5.3644
211.240	62.17	1.0103629	5.5368
372.174	113.11	1.0192131	5.6258
494.738	154.27	1.0263571	5.6453
657.416	212.46	1.0366248	5.6766
847.166	286.22	1.0499351	5.7201
844.194	285.01	1.0497819	5.7271
783.897	260.86	1.0454349	5.7190
673.112	218.31	1.0378280	5.7038
581.604	184.81	1.0318832	5.6901
270.679	80.60	1.0136439	5.6169
127.906	37.04	1.0061352	5.5085
210.359	61.90	1.0102467	5.4988
157.445	45.86	1.0075137	5.4474
237.768	70.34	1.0117495	5.5459
322.926	97.16	1.0164030	5.5963
131.456	38.10	1.0061913	5.4051
183.721	53.78	1.0088732	5.4828
284.373	84.91	1.0142270	5.5587
349.250	105.65	1.0178266	5.5911
440.319	135.73	1.0230651	5.6212
516.589	161.84	1.0278318	5.6795

TABLE 1.- Dielectric constants for H_2-CO_2 system at 30° C (Cond.)

Pressure, (bars)	Density, (moles/cm^3) x 10^2	Dielectric constant	CH_3, (cm^3)
Composition 24.12 H_2 - 75.88 CO_2			
1.013	0.0000	1.000548	0.0100
5.066	0.0211	1.001111	0.1110
10.132	0.0423	1.001686	0.2120
15.199	0.0636	1.002272	0.3130
20.265	0.0850	1.002870	0.4140
25.331	0.1065	1.003480	0.5150
30.397	0.1281	1.004102	0.6160
35.463	0.1498	1.004736	0.7170
40.529	0.1716	1.005383	0.8180
45.595	0.1935	1.006042	0.9190
50.662	0.2156	1.006714	1.0200
55.728	0.2378	1.007399	1.1210
60.794	0.2601	1.008097	1.2220
65.860	0.2826	1.008808	1.3230
70.926	0.3052	1.009533	1.4240
75.992	0.3280	1.010271	1.5250
Composition 48.17 H_2 - 51.83 CO_2			
1.013	0.0000	1.000925	0.0100
5.066	0.0423	1.004625	0.0460
10.132	0.0850	1.009333	0.0920
15.199	0.1281	1.014050	0.1390
20.265	0.1716	1.018776	0.1860
25.331	0.2156	1.023511	0.2340
30.397	0.2601	1.028255	0.2820
35.463	0.3052	1.033008	0.3310
40.529	0.3508	1.037770	0.3810
45.595	0.3970	1.042541	0.4320
50.662	0.4438	1.047321	0.4840
55.728	0.4913	1.052110	0.5370
60.794	0.5394	1.056908	0.5910
65.860	0.5883	1.061715	0.6460
70.926	0.6380	1.066531	0.7020
75.992	0.6885	1.071356	0.7590
Composition 72.43 H_2 - 27.57 CO_2			
1.013	0.0000	1.000925	0.0100
5.066	0.0636	1.006944	0.0690
10.132	0.1281	1.013009	0.1300
15.199	0.1935	1.019120	0.1940
20.265	0.2601	1.025277	0.2610
25.331	0.3280	1.031480	0.3310
30.397	0.3970	1.037730	0.4040
35.463	0.4674	1.044026	0.4810
40.529	0.5394	1.050369	0.5620
45.595	0.6131	1.056759	0.6470
50.662	0.6885	1.063196	0.7370
55.728	0.7658	1.069681	0.8320
60.794	0.8452	1.076214	0.9320
65.860	0.9268	1.082795	1.0380
70.926	1.0108	1.089425	1.1500
75.992	1.0974	1.096104	1.2690

TABLE 1.- Dielectric constants for He-CO_2 system at 20° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM_3, (cm^3)
	Composition 24.7% He - 74.6% CO_2		
578.336	183.64	1.0316889	5.6918
643.199	207.20	1.0358986	5.7067
708.968	231.83	1.0402715	5.7134
	Composition 8.11% He - 91.89% CO_2		
59.492	17.14	1.0035856	6.9613
109.874	32.19	1.0066713	6.8923
207.826	62.94	1.0130321	6.8713
302.141	94.69	1.0196423	6.8691
407.978	133.33	1.0277914	6.8838
506.390	172.81	1.0361629	6.8923
597.483	213.20	1.0448499	6.9088
698.789	263.75	1.0559168	6.9375
733.292	282.64	1.0600655	6.9448
679.102	253.38	1.0536837	6.9380
565.464	198.52	1.0417676	6.9167
337.392	107.18	1.0223153	6.8888
253.162	77.92	1.0161830	6.8854
149.117	44.26	1.0091873	6.8974
61.379	17.70	1.0037112	6.9792
11.723	3.32	1.0007632	7.6419
121.775	35.81	1.0074375	6.9040
211.228	64.05	1.0132894	6.8854
310.646	97.67	1.0203002	6.8812
403.308	131.55	1.0274342	6.8882
496.974	168.86	1.0353736	6.9013
595.048	212.06	1.0446472	6.9148
675.896	251.72	1.0532637	6.9301
648.642	237.88	1.0502847	6.9298
553.276	193.07	1.0405914	6.9141
445.437	147.91	1.0309461	6.9026
340.310	108.23	1.0225480	6.8926
238.389	72.98	1.0151675	6.8921
147.243	43.68	1.0090773	6.9061
47.022	13.50	1.0028618	7.0592

TABLE I.- Dielectric constants for $He-CO_2$ system at 30° C (Con.)

Pressure, (bars)	Density, (moles/cm^3) x 10^2	Dielectric constant	CM^2, (cm^3)
Composition 24.72 He - 75.28 CO_2			
2.1834	1.0415215	1.0058	58.24
2.1073	1.0328826	1.0056	58.01
2.0318	1.0241988	1.0054	57.78
1.9568	1.0155700	1.0052	57.55
1.8824	1.0069962	1.0050	57.32
1.8086	0.9984774	1.0048	57.09
1.7353	0.9900136	1.0046	56.86
1.6626	0.9816048	1.0044	56.63
1.5904	0.9732510	1.0042	56.40
1.5188	0.9649522	1.0040	56.17
1.4477	0.9567084	1.0038	55.94
1.3772	0.9485196	1.0036	55.71
1.3072	0.9403858	1.0034	55.48
1.2378	0.9323070	1.0032	55.25
1.1689	0.9242832	1.0030	55.02
1.1005	0.9163144	1.0028	54.79
1.0327	0.9084006	1.0026	54.56
0.9654	0.9005418	1.0024	54.33
0.8986	0.8927380	1.0022	54.10
0.8324	0.8849892	1.0020	53.87
0.7667	0.8772954	1.0018	53.64
0.7015	0.8696566	1.0016	53.41
0.6369	0.8620728	1.0014	53.18
0.5728	0.8545440	1.0012	52.95
0.5092	0.8470702	1.0010	52.72
0.4462	0.8396514	1.0008	52.49
0.3837	0.8322876	1.0006	52.26
0.3217	0.8249788	1.0004	52.03
0.2603	0.8177250	1.0002	51.80
0.1994	0.8105262	1.0000	51.57
Composition 45.12 He - 54.88 CO_2			
2.1834	1.0415215	1.0058	58.24
2.1073	1.0328826	1.0056	58.01
2.0318	1.0241988	1.0054	57.78
1.9568	1.0155700	1.0052	57.55
1.8824	1.0069962	1.0050	57.32
1.8086	0.9984774	1.0048	57.09
1.7353	0.9900136	1.0046	56.86
1.6626	0.9816048	1.0044	56.63
1.5904	0.9732510	1.0042	56.40
1.5188	0.9649522	1.0040	56.17
1.4477	0.9567084	1.0038	55.94
1.3772	0.9485196	1.0036	55.71
1.3072	0.9403858	1.0034	55.48
1.2378	0.9323070	1.0032	55.25
1.1689	0.9242832	1.0030	55.02
1.1005	0.9163144	1.0028	54.79
1.0327	0.9084006	1.0026	54.56
0.9654	0.9005418	1.0024	54.33
0.8986	0.8927380	1.0022	54.10
0.8324	0.8849892	1.0020	53.87
0.7667	0.8772954	1.0018	53.64
0.7015	0.8696566	1.0016	53.41
0.6369	0.8620728	1.0014	53.18
0.5728	0.8545440	1.0012	52.95
0.5092	0.8470702	1.0010	52.72
0.4462	0.8396514	1.0008	52.49
0.3837	0.8322876	1.0006	52.26
0.3217	0.8249788	1.0004	52.03
0.2603	0.8177250	1.0002	51.80
0.1994	0.8105262	1.0000	51.57

TABLE 1.- Dielectric constants for $He-CO_2$ system at 20° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM_3, (cm^3)
	Composition 5.83% He - 94.17% CO_2		
18.187	5.17	1.0010779	6.9388
26.053	7.43	1.0015498	6.9445
37.629	10.78	1.0022461	6.9391
48.548	13.96	1.0029213	6.9677
68.724	19.90	1.0041547	6.9490
110.135	32.35	1.0067664	6.9546
128.701	38.06	1.0079686	6.9600
147.938	44.05	1.0092309	6.9631
165.041	49.45	1.0103730	6.9678
187.482	56.64	1.0119128	6.9829
187.469	56.63	1.0119148	6.9846
210.408	64.11	1.0134997	6.9871
228.110	69.97	1.0147650	6.9990
249.289	77.09	1.0162587	6.9916
269.562	84.03	1.0177344	6.9935
291.103	91.52	1.0193373	6.9972
309.665	98.10	1.0207469	7.0010
328.240	104.78	1.0221835	7.0048
344.693	110.80	1.0234839	7.0098
364.624	118.21	1.0250798	7.0130
386.617	126.56	1.0268831	7.0174
405.879	134.02	1.0284981	7.0212
398.465	131.13	1.0278739	7.0201
380.308	124.14	1.0263972	7.0256
359.805	116.41	1.0247182	7.0199
358.551	115.94	1.0247683	7.0624
358.489	115.92	1.0247683	7.0639
267.091	83.17	1.0177254	7.0615
267.153	83.20	1.0177264	7.0601
152.691	45.54	1.0096747	7.0575
50.596	14.56	1.0031107	7.1137
12.728	3.61	1.0008004	7.3767
109.986	32.31	1.0067874	6.9860
210.992	64.30	1.0135467	6.9904
301.706	95.26	1.0201548	7.0047
405.866	134.01	1.0285842	7.0425
439.500	147.39	1.0314915	7.0476
483.148	165.50	1.0354257	7.0515

TABLE I.- Dielectric constants for H_2O-CO_2 system at 30° C (Con.)

Pressure (bars)	Density, ρ (moles/cm^3) x 10^2	Dielectric constant	CM^2 (cm^3)
Composition 2.83% H_2O - 96.11% CO_2			
18.181	2.11	1.0010100	8.8882
30.023	4.243	1.0015498	8.8442
37.659	10.18	1.0055600	8.1616
44.248	13.89	1.0092512	8.0480
48.457	16.90	1.0114004	7.9613
51.852	19.05	1.0130600	7.8962
110.132	35.32	1.0300444	8.2548
158.107	38.80	1.0301700	7.9886
141.838	44.02	1.0316600	7.8396
181.040	49.42	1.0331430	7.8196
181.484	50.04	1.0331110	7.8186
181.694	50.63	1.0331810	7.8166
208.804	44.11	1.0313694	7.8166
222.004	49.63	1.0314020	7.8166
241.852	16.69	1.0314020	7.8166
841.284	20.191	1.0325420	7.8150
664.200	46.141	1.0316160	7.8140
598.204	10.361	1.0328420	7.8140
601.106	62.56	1.0321050	7.8100
566.012	66.39	1.0332410	7.7966
886.601	16.35	1.0318600	7.7960
851.21	19.3	1.0308000	7.7916
965.02	92.41	1.0311600	7.7911
169.521	92.59	1.0319800	7.7900
521.162	02.68	1.0321110	7.7890
160.162	11.68	1.0325110	7.7890
684.826	56.511	1.0301420	7.7890
122.826	96.511	1.0301420	7.7890
508.626	14.911	1.0301420	7.7890
806.086	41.421	1.0316320	7.7850
549.866	61.161	1.0318120	7.7850
618.204	50.361	1.0318480	7.7850
719.086	95.851	1.0388020	7.7850
459.496	15.811	1.0310220	7.7850
569.446	08.011	1.0318420	7.7850
045.856	81.401	1.0321550	7.7800
599.606	01.86	1.0321050	7.7800
501.162	52.16	1.0316610	7.7766
595.695	60.48	1.0317110	7.7766
685.625	60.11	1.0325910	7.7766
011.855	16.69	1.0321020	7.7766
804.015	44.11	1.0313694	7.7760
181.494	52.63	1.0311810	7.7760
181.285	52.44	1.0311110	7.7760
182.041	44.42	1.0316010	7.7760
141.838	44.02	1.0325600	7.7760
158.107	38.80	1.0031700	7.7760
110.132	35.32	1.0032400	7.7760
84.254	19.90	1.0041202	7.7760
84.248	13.96	1.0032512	7.7760
32.659	10.18	1.0055600	7.7616
30.023	4.243	1.0015498	7.7444
18.181	2.11	1.0010100	7.7388

TABLE 1.- Dielectric constants for He-CO_2 system at 20° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM, (cm^3)
Composition 5.83% He - 94.17% CO_2			
522.950	182.82	1.0392146	7.0573
562.730	201.01	1.0432430	7.0689
603.398	220.61	1.0475729	7.0755
639.707	239.10	1.0516824	7.0829
687.031	264.78	1.0574279	7.0937
711.926	279.10	1.0606658	7.1015
674.641	257.87	1.0559142	7.0953
633.109	235.67	1.0509331	7.0837
568.247	203.61	1.0439052	7.0841
532.702	187.20	1.0402676	7.0751
488.241	167.67	1.0359978	7.0713
433.203	144.85	1.0310107	7.0629
393.745	129.30	1.0276335	7.0585
353.870	114.19	1.0244066	7.0664
316.705	100.62	1.0214732	7.0629
288.346	90.56	1.0192963	7.0571
211.848	64.58	1.0137692	7.0737
157.916	47.19	1.0102768	7.2335
132.734	39.31	1.0085647	7.2415
101.125	29.61	1.0064759	7.2728
73.204	21.23	1.0046585	7.3023
42.741	12.26	1.0027390	7.4356
20.693	5.89	1.0013574	7.6726
25.966	7.41	1.0016420	7.3821
11.177	3.17	1.0007593	7.9736
57.855	16.69	1.0035906	7.1619
88.442	25.78	1.0054941	7.0886
128.080	37.87	1.0080497	7.0663
163.700	49.02	1.0104091	7.0526
207.020	63.00	1.0133725	7.0439
245.341	75.76	1.0160935	7.0431
287.688	90.33	1.0192312	7.0513
487.259	167.25	1.0358988	7.0698
564.197	201.70	1.0434897	7.0844
644.156	241.43	1.0523319	7.1011
707.066	276.26	1.0601813	7.1184
680.457	261.10	1.0567620	7.1119

TABLE 1.- Dielectric constants for He-CO_2 system at 20° C (Con.)

Pressure, (psia)	Density, (moles/cm³) x 10²	Dielectric constant	CM, (cm³)
Composition 5.83% He - 94.17% CO_2			
522.950	182.82	1.0392146	7.0573
562.730	201.01	1.0432430	7.0689
603.398	220.61	1.0472529	7.0753
639.707	239.10	1.0516824	7.0829
687.031	264.78	1.0574279	7.0937
711.926	279.10	1.0606658	7.1015
674.641	257.87	1.0559142	7.0953
633.109	235.67	1.0509331	7.0837
568.247	203.61	1.0439032	7.0841
532.702	187.20	1.0402676	7.0751
488.241	167.67	1.0359978	7.0713
433.203	146.85	1.0310107	7.0629
393.745	129.30	1.0276335	7.0585
353.870	114.19	1.0244066	7.0664
316.705	100.62	1.0214732	7.0629
288.346	90.56	1.0192963	7.0571
211.848	64.58	1.0137692	7.0737
157.916	47.19	1.0102768	7.2333
132.734	39.31	1.0085647	7.2415
101.125	29.61	1.0064739	7.2728
73.204	21.23	1.0046585	7.3023
42.741	12.26	1.0027390	7.4336
20.693	5.89	1.0013574	7.6726
25.966	7.41	1.0016420	7.3821
11.177	3.17	1.0007593	7.9736
57.855	16.69	1.0035906	7.1619
88.442	25.78	1.0054941	7.0886
128.080	37.87	1.0080497	7.0663
163.700	49.02	1.0104091	7.0526
207.020	63.00	1.0133725	7.0439
245.341	75.76	1.0160935	7.0431
287.688	90.33	1.0192312	7.0513
487.259	167.25	1.0358988	7.0698
564.197	201.70	1.0434897	7.0844
644.156	241.43	1.0523319	7.1011
707.066	276.26	1.0601813	7.1184
680.457	261.10	1.0567620	7.1119

TABLE 1.- Dielectric constants for He-CO_2 system at 20° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM, (cm^3)
	Composition 5.83% He - 94.17% CO_2		
614.357	226.09	1.0489357	7.0987
535.572	188.49	1.0406194	7.0869
430.271	143.67	1.0307874	7.0700
379.178	123.71	1.0264164	7.0551
329.519	105.25	1.0224622	7.0609
255.012	79.04	1.0168388	7.0615
176.162	52.99	1.0112957	7.0775
97.737	28.59	1.0061232	7.1243
55.472	15.99	1.0034914	7.2694
39.168	11.22	1.0024775	7.3489
17.802	5.06	1.0011771	7.7418
594.613	216.29	1.0466913	7.0854
68.724	19.90	1.0041546	6.9488
89.088	25.98	1.0054349	6.9600
	Composition 100% CO_2		
14.775	4.20	1.0007593	6.0217
14.862	4.22	1.0007593	5.9863
87.412	25.56	1.0054749	7.1254
353.435	116.64	1.0259822	7.3612
518.924	189.32	1.0428208	7.4331
703.972	301.75	1.0696164	7.5157
774.848	361.91	1.0852178	7.6319
604.081	235.29	1.0536755	7.4703
407.084	138.37	1.0311095	7.4170
212.841	65.61	1.0145063	7.3336
39.453	11.32	1.0023493	6.9087
115.173	34.06	1.0071140	6.9454
206.461	63.46	1.0136499	7.1362
294.927	94.47	1.0206697	7.2426
389.386	131.04	1.0289649	7.2974
149.948	44.98	1.0095655	7.0650
76.517	22.28	1.0045303	6.7667
76.381	22.24	1.0045583	6.8210
168.181	50.84	1.0108919	7.1143
183.684	55.90	1.0120229	7.1398
225.838	70.03	1.0151847	7.1911
288.098	91.98	1.0201267	7.2449
361.234	119.71	1.0264012	7.2871

Frequency, (hertz)	Density, (moles/cm^3) x 10^2	Dielectric constant	CM, (cm^3)
Composition 2.83% He - 97.17% CO_2			
5.0	2.0	1.000 1525	0.1525
10.0	2.0	1.000 1525	0.1525
20.0	2.0	1.000 1525	0.1525
50.0	2.0	1.000 1525	0.1525
100.0	2.0	1.000 1525	0.1525
200.0	2.0	1.000 1525	0.1525
500.0	2.0	1.000 1525	0.1525
1000.0	2.0	1.000 1525	0.1525
2000.0	2.0	1.000 1525	0.1525
5000.0	2.0	1.000 1525	0.1525
10000.0	2.0	1.000 1525	0.1525
20000.0	2.0	1.000 1525	0.1525
50000.0	2.0	1.000 1525	0.1525
100000.0	2.0	1.000 1525	0.1525
Composition 5.12% He - 94.88% CO_2			
5.0	4.0	1.000 2563	0.2563
10.0	4.0	1.000 2563	0.2563
20.0	4.0	1.000 2563	0.2563
50.0	4.0	1.000 2563	0.2563
100.0	4.0	1.000 2563	0.2563
200.0	4.0	1.000 2563	0.2563
500.0	4.0	1.000 2563	0.2563
1000.0	4.0	1.000 2563	0.2563
2000.0	4.0	1.000 2563	0.2563
5000.0	4.0	1.000 2563	0.2563
10000.0	4.0	1.000 2563	0.2563
20000.0	4.0	1.000 2563	0.2563
50000.0	4.0	1.000 2563	0.2563
100000.0	4.0	1.000 2563	0.2563

TABLE 1.- Dielectric constants for He-CO_2 system at 30° C (Con.)

TABLE 1.- Dielectric constants for He-CO_2 system at 20° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM, (cm^3)
	Composition 100% CO_2		
448.020	156.03	1.0346883	7.3257
745.151	335.00	1.0769184	7.4621
653.539	266.09	1.0608781	7.4742
628.473	250.03	1.0570742	7.4666
592.165	228.37	1.0519288	7.4504
526.006	192.86	1.0435926	7.4261
463.994	163.21	1.0367230	7.4094
425.105	146.02	1.0327498	7.3951
368.175	122.46	1.0273038	7.3644
313.663	101.41	1.0224630	7.3281
267.265	84.48	1.0185949	7.2915
186.898	56.96	1.0123706	7.2090
103.607	30.49	1.0064217	7.0037
53.326	15.38	1.0030516	6.6028
53.412	15.41	1.0030566	6.6026
49.442	14.24	1.0028302	6.6151
91.235	26.72	1.0055752	6.9412
129.408	38.49	1.0081850	7.0682
165.301	49.91	1.0107196	7.1329
207.740	63.89	1.0138333	7.1831
245.639	76.86	1.0167336	7.2164
287.862	91.89	1.0201218	7.2499
326.365	106.20	1.0233447	7.2703
363.481	120.60	1.0266056	7.2889
11.437	3.24	1.0008175	8.3843
29.515	8.44	1.0019676	7.7646
11.785	3.34	1.0008375	8.3355
11.549	3.28	1.0008205	8.3335
30.433	8.70	1.0020237	7.7423
51.911	14.97	1.0034103	7.5832
50.782	14.64	1.0033592	7.6391
40.570	11.65	1.0026809	7.6627
88.120	25.77	1.0058137	7.5027
130.910	38.96	1.0087541	7.4669
165.264	49.90	1.0112036	7.4556
210.048	64.67	1.0145227	7.4488

composition 100% CO_2

Pressure (bars)	Density (moles/cm^3) x 10_2	Dielectric constant	CM_3 (cm^3)
150.03	1.0369883	1.0315370	0.0000
200.00	1.0432459	1.0402049	0.0000
250.00	1.0495630	1.0482501	0.0000
300.00	1.0559430	1.0562049	0.0000
350.00	1.0623898	1.0641526	0.0000
400.00	1.0689070	1.0721048	0.0000
450.00	1.0754982	1.0801090	0.0000
500.00	1.0821670	1.0881696	0.0000
550.00	1.0889170	1.0962910	0.0000
600.00	1.0957523	1.1044775	0.0000
650.00	1.1026770	1.1127339	0.0000
700.00	1.1096955	1.1210650	0.0000
750.00	1.1168123	1.1294759	0.0000
800.00	1.1240321	1.1379719	0.0000
850.00	1.1313598	1.1465587	0.0000
900.00	1.1388007	1.1552421	0.0000
950.00	1.1463603	1.1640284	0.0000
1000.00	1.1540446	1.1729241	0.0000

TABLE I.- Dielectric constants for He-CO_2 system at 50° C (Con.)

TABLE 1.- Dielectric constants for He-CO_2 system at 20° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM, (cm^3)
	Composition 100% CO_2		
186.017	56.67	1.0127304	7.4558
144.127	43.13	1.0096968	7.4691
105.369	31.03	1.0069949	7.4945
207.342	63.76	1.0143494	7.4654
165.773	50.06	1.0112787	7.4807
123.041	36.50	1.0082401	7.5035
81.059	23.64	1.0053578	7.5388
42.133	12.10	1.0027911	7.6768
11.735	3.33	1.0008445	8.4410
56.874	16.43	1.0037369	7.5690
110.308	32.55	1.0073345	7.4907
154.007	46.28	1.0103901	7.4571
205.046	62.99	1.0141560	7.4553
110.445	32.60	1.0073042	7.4502
212.171	65.39	1.0146486	7.4308
302.600	97.30	1.0218837	7.4424
394.801	133.26	1.0301065	7.4555
497.905	179.05	1.0407102	7.4773
592.202	228.39	1.0522706	7.4979
707.390	304.36	1.0706113	7.5554
804.286	391.60	1.0943882	7.7891
757.730	346.06	1.0815236	7.6445
651.662	264.86	1.0611465	7.5416
547.076	203.68	1.0465861	7.5071
440.580	152.74	1.0347082	7.4875
332.996	108.73	1.0245612	7.4684
233.038	72.50	1.0163093	7.4578
143.780	43.02	1.0096772	7.4732
43.982	12.64	1.0028999	7.6351
11.772	3.34	1.0008324	8.2932

Pressure, (bars)	Density, (10^2 moles/cm^3)	Dielectric constant	CM, (cm^3)
Composition 100% CO_2			

TABLE 2.- Dielectric constants for He-CO_2 system at 0° C

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM, (cm^3)
	Composition 100% He		
1010.928	296.09	1.004614	0.5186
918.010	269.75	1.0042053	.5189
602.955	179.14	1.0027978	.5200
300.146	90.14	1.0014144	.5227
11.603	3.52	1.0000691	.6542
111.988	33.86	1.0005319	.5235
11.678	3.54	1.0000611	.5747
212.238	63.94	1.0009937	.5178
310.551	93.23	1.0014485	.5176
406.355	121.58	1.0018883	.5173
509.177	151.78	1.0023561	.5170
606.223	180.09	1.0027948	.5167
707.693	209.49	1.0032506	.5166
809.810	238.86	1.0037164	.5179
910.723	267.67	1.0041622	.5175
1013.615	296.85	1.004616	.5175
965.953	283.36	1.0044076	.5177
861.507	253.64	1.0039458	.5178
753.707	222.75	1.0034660	.5180
649.306	192.60	1.0029972	.5181
548.099	163.16	1.0025404	.5185
443.417	132.49	1.0020646	.5190
343.257	102.93	1.0016037	.5190
245.395	73.84	1.0011519	.5198
142.233	42.95	1.0006721	.5214
47.002	14.24	1.0002273	.5320
10.970	3.32	1.0000571	.5716

Pressure (bars)	Density (moles/cm^3) x 10_2	Dielectric constant	CH$_4$ (cm^3)
	Composition 100% H_2		

TABLE 2.- Dielectric constants for He-CO_2 system at 0° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM, (cm^3)
	Composition 94.72% He - 5.28% CO_2		
115.247	34.84	1.0009316	0.8910
212.407	63.98	1.0017009	.8856
311.887	93.60	1.0024853	.8842
405.183	121.18	1.0032156	.8835
509.942	151.92	1.0040280	.8825
611.946	181.61	1.0048134	.8820
639.893	189.71	1.0050258	.8815
556.145	165.40	1.0044057	.8865
445.648	133.09	1.0035502	.8881
348.406	104.42	1.0027909	.8900
247.215	74.37	1.0019945	.8932
146.199	44.14	1.0011930	.9004
44.937	13.62	1.0003866	.9461
25.308	7.67	1.0002274	.9873
132.895	40.15	1.0011470	.9518
291.127	87.44	1.0024022	.9149
422.173	126.19	1.0034250	.9036
583.479	173.35	1.0046691	.8963
478.141	142.62	1.0038467	.8978
326.663	97.98	1.0026566	.9029
180.121	54.32	1.0014855	.9111
77.398	23.43	1.0006571	.9346
11.859	3.59	1.0001252	1.1597
	Composition 89.13% He - 10.87% CO_2		
114.217	34.54	1.0013233	1.2762
211.761	63.83	1.0024352	1.2704
307.343	92.35	1.0035171	1.2679
407.667	122.06	1.0046451	1.2664
510.663	152.34	1.0057971	1.2659
609.921	181.30	1.0069010	1.2658
666.152	197.60	1.0075210	1.2655
563.587	167.81	1.0063881	1.2661
450.690	134.74	1.0051409	1.2695
352.466	105.74	1.0040380	1.2711
244.260	73.55	1.0028159	1.2748

TABLE 5.- Dielectric constants for He-CO_2 system at 0° C (Con.)

Pressure (bars)	Density x 10^2 (moles/cm^3)	Dielectric constant	CM_3 (cm^3)
Composition 98.137 He - 1.863 CO_2			
34.24	4.3	1.0001335	1.1525
83.63	8.3	1.0002534	1.1507
125.30	12.4	1.0003844	1.1495
181.05	17.9	1.0005700	1.1482
221.75	21.9	1.0006980	1.1474
263.46	26.0	1.0008300	1.1465
303.17	29.9	1.0009600	1.1458
343.88	33.9	1.0010900	1.1451
384.59	37.9	1.0012200	1.1445
425.30	41.9	1.0013500	1.1439
465.01	45.8	1.0014800	1.1434
505.72	49.8	1.0016100	1.1429
546.43	53.8	1.0017400	1.1424
587.14	57.8	1.0018700	1.1419
627.85	61.8	1.0020000	1.1415
668.56	65.8	1.0021300	1.1411
709.27	69.8	1.0022600	1.1407
749.98	73.8	1.0023900	1.1403
790.69	77.8	1.0025200	1.1400
831.40	81.8	1.0026500	1.1396
872.11	85.8	1.0027800	1.1393
912.82	89.8	1.0029100	1.1390
953.53	93.8	1.0030400	1.1387
994.24	97.8	1.0031700	1.1384
1034.95	101.8	1.0033000	1.1381
1075.66	105.8	1.0034300	1.1378
1116.37	109.8	1.0035600	1.1376
1157.08	113.8	1.0036900	1.1373
1197.79	117.8	1.0038200	1.1371
1238.50	121.8	1.0039500	1.1368
1279.21	125.8	1.0040800	1.1366
1319.92	129.8	1.0042100	1.1364
1360.63	133.8	1.0043400	1.1362
1401.34	137.8	1.0044700	1.1360
1442.05	141.8	1.0046000	1.1358
1482.76	145.8	1.0047300	1.1356
1523.47	149.8	1.0048600	1.1354
1564.18	153.8	1.0049900	1.1352
1604.89	157.8	1.0051200	1.1350
1645.60	161.8	1.0052500	1.1348
1686.31	165.8	1.0053800	1.1346
1727.02	169.8	1.0055100	1.1345
1767.73	173.8	1.0056400	1.1343
1808.44	177.8	1.0057700	1.1341
Composition 97.137 He - 2.863 CO_2			
34.24	4.3	1.0001335	1.1525
83.63	8.3	1.0002534	1.1507
125.30	12.4	1.0003844	1.1495
181.05	17.9	1.0005700	1.1482
221.75	21.9	1.0006980	1.1474
263.46	26.0	1.0008300	1.1465
303.17	29.9	1.0009600	1.1458
343.88	33.9	1.0010900	1.1451
384.59	37.9	1.0012200	1.1445
425.30	41.9	1.0013500	1.1439
465.01	45.8	1.0014800	1.1434
505.72	49.8	1.0016100	1.1429
546.43	53.8	1.0017400	1.1424
587.14	57.8	1.0018700	1.1419
627.85	61.8	1.0020000	1.1415
668.56	65.8	1.0021300	1.1411
709.27	69.8	1.0022600	1.1407
749.98	73.8	1.0023900	1.1403
790.69	77.8	1.0025200	1.1400
831.40	81.8	1.0026500	1.1396
872.11	85.8	1.0027800	1.1393
912.82	89.8	1.0029100	1.1390
953.53	93.8	1.0030400	1.1387
994.24	97.8	1.0031700	1.1384
1034.95	101.8	1.0033000	1.1381
1075.66	105.8	1.0034300	1.1378
1116.37	109.8	1.0035600	1.1376
1157.08	113.8	1.0036900	1.1373
1197.79	117.8	1.0038200	1.1371
1238.50	121.8	1.0039500	1.1368
1279.21	125.8	1.0040800	1.1366
1319.92	129.8	1.0042100	1.1364
1360.63	133.8	1.0043400	1.1362
1401.34	137.8	1.0044700	1.1360
1442.05	141.8	1.0046000	1.1358
1482.76	145.8	1.0047300	1.1356
1523.47	149.8	1.0048600	1.1354
1564.18	153.8	1.0049900	1.1352
1604.89	157.8	1.0051200	1.1350
1645.60	161.8	1.0052500	1.1348
1686.31	165.8	1.0053800	1.1346
1727.02	169.8	1.0055100	1.1345
1767.73	173.8	1.0056400	1.1343
1808.44	177.8	1.0057700	1.1341

TABLE 2.- Dielectric constants for He-CO_2 system at 0° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM_3, (cm^3)
	Composition 89.13% He - 10.87% CO_2		
146.820	44.35	1.0017079	1.2827
49.652	15.04	1.0005950	1.3176
26.983	8.18	1.0003335	1.3583
135.613	40.98	1.0015907	1.2929
230.046	69.30	1.0026666	1.2813
485.632	145.01	1.0055396	1.2710
631.319	187.51	1.0071594	1.2696
327.818	98.43	1.0037685	1.2745
73.415	22.23	1.0008695	1.3031
11.065	3.35	1.0001492	1.4815
	Composition 73.03% He - 26.97% CO_2		
118.635	35.95	1.0025885	2.3975
712.846	213.93	1.0154638	2.3970
607.051	182.54	1.0131788	2.3959
504.688	152.03	1.0109650	2.3952
399.309	120.50	1.0086860	2.3956
303.580	91.75	1.0066145	2.3975
200.105	60.57	1.0043736	2.4030
97.848	29.66	1.0021587	2.4238
50.570	15.34	1.0011329	2.4605
160.969	48.75	1.0035652	2.4343
255.086	77.15	1.0056137	2.4206
353.497	106.76	1.0077544	2.4148
453.237	136.65	1.0099182	2.4112
556.903	167.61	1.0121661	2.4096
655.079	196.81	1.0142928	2.4092
534.838	161.03	1.0116822	2.4087
380.581	114.89	1.0083344	2.4113
224.485	67.93	1.0049355	2.4177
120.795	36.61	1.0026756	2.4338
77.795	23.59	1.0017390	2.4555
28.546	8.66	1.0006591	2.5355
11.300	3.43	1.0002814	2.7350

Pressure (bars)	Density (moles/cm^3) x 10^2	Dielectric constant	CN^2 (cm^2)
Composition 89.13% He - 10.87% CO$_2$			
140.850	44.35	1.0017019	1.5851
94.525	12.04	1.0002620	1.3159
58.883	8.18	1.0002222	1.3583
132.613	40.88	1.0012103	1.5852
230.044	69.20	1.0020888	1.5813
284.635	142.01	1.0022536	1.5110
631.316	181.21	1.0021295	1.5696
842.815	86.43	1.0012603	1.5242
63.412	22.53	1.0008062	1.3031
11.065	3.35	1.0001693	1.2815
Composition 17.03% He - 82.97% CO$_2$			
300.011	93.8	1.0018500	1.5839
945.82	99.8	1.0059000	1.5252
561.121	65.63	1.0021100	1.5224
561.021	19.96	1.0012500	1.5138
584.422	56.19	1.0014400	1.5114
182.086	68.411	1.0044800	1.5114
868.465	60.191	1.0038110	1.5004
616.259	18.961	1.0025610	1.5004
606.955	19.191	1.0012510	1.5004
165.654	59.361	1.0016600	1.5114
169.655	91.901	1.0025100	1.5149
980.555	51.11	1.0019500	1.5029
696.091	51.89	1.0025600	1.5434
015.05	36.51	1.0013100	1.5049
848.16	99.65	1.0021500	1.5434
501.005	15.09	1.0004300	1.5040
085.505	51.18	1.0019900	1.5436
666.606	150.05	1.0038800	1.5446
889.405	60.251	1.0029010	1.5436
150.109	94.281	1.0014510	1.5436
948.514	56.513	1.0029210	1.5430
559.811	56.55	1.0025200	1.5436

TABLE 3.- Dielectric constants for He-CO_2 mixtures at 0° C (Con.)

TABLE 2.- Dielectric constants for $He-CO_2$ system at 0° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM_3, (cm^3)
Composition 48.8% He - 51.2% CO_2			
112.683	34.53	1.0042173	4.0649
209.321	64.66	1.0078546	4.0383
310.116	96.58	1.0117292	4.0320
405.424	127.23	1.0154707	4.0322
502.568	158.92	1.0193624	4.0351
605.863	193.10	1.0235867	4.0396
705.120	226.42	1.0277249	4.0441
659.558	211.07	1.0258186	4.0425
560.635	178.07	1.0217576	4.0433
460.818	145.24	1.0177066	4.0396
354.843	110.91	1.0135013	4.0393
250.112	77.52	1.0094363	4.0446
147.681	45.39	1.0055416	4.0619
48.044	14.64	1.0018312	4.1654
28.589	8.70	1.0011099	4.2508
81.820	25.01	1.0030633	4.0783
235.538	72.91	1.0088503	4.0338
478.618	151.06	1.0183927	4.0336
632.181	201.89	1.0246766	4.0408
371.123	116.15	1.0141424	4.0394
119.546	36.65	1.0044948	4.0809
11.454	3.48	1.0004868	4.6612
Composition 21.6% He - 78.4% CO_2			
116.128	36.25	1.0064692	5.9357
208.062	66.47	1.0118715	5.9294
302.898	99.23	1.0178218	5.9511
397.843	133.82	1.0242149	5.9833
502.514	174.28	1.0318541	6.0282
610.381	218.88	1.0405030	6.0858
704.133	260.36	1.0488194	6.1500
661.479	241.15	1.0449547	6.1219
566.308	200.28	1.0369058	6.0676
454.355	155.34	1.0282949	6.0146
347.809	115.35	1.0208290	5.9770
248.270	80.15	1.0143829	5.9525

Pressure (bars)	Density (moles/cm^3) x 10^2	Dielectric constant	CH_3 (cm^3)
	CO_2 25.87 - 28.15 mole% N_2 combination		
	CO_2 21.12 - 28.84 mole% N_2 combination		

TABLE 5.- Dielectric constants for N_2-CO_2 system at 0° C (Cole')

TABLE 2.- Dielectric constants for He-CO_2 system at 0° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM, (cm^3)
	Composition 21.6% He - 78.4% CO_2		
144.350	45.37	1.0081180	5.9471
49.640	15.24	1.0027628	6.0342
29.018	8.86	1.0016348	6.1403
131.021	41.05	1.0073116	5.9225
290.593	94.88	1.0170194	5.9451
429.402	145.75	1.0264457	5.9952
578.969	205.57	1.0378885	6.0669
676.741	247.96	1.0463011	6.1295
385.039	129.04	1.0234075	5.9994
236.576	76.14	1.0136746	5.9588
80.860	25.02	1.0044988	5.9834
13.745	4.18	1.0008104	6.4510
	Composition 8.11% He - 91.89% CO_2		
111.623	35.46	1.0073868	6.9249
208.136	69.03	1.0143479	6.8953
305.418	106.29	1.0221735	6.9024
406.301	149.78	1.0314516	6.9265
503.035	197.96	1.0418898	6.9563
554.207	226.93	1.0483049	6.9829
457.460	174.32	1.0368079	6.9529
360.761	129.43	1.0271151	6.9201
252.144	85.40	1.0178049	6.9082
146.348	47.20	1.0098241	6.9147
47.754	14.77	1.0031334	7.0604
24.713	7.57	1.0016548	7.2763
89.162	28.06	1.0058632	6.9501
12.504	3.81	1.0008855	7.7348
	Composition 5.8% He - 94.2% CO_2		
112.132	35.78	1.0076132	7.0741
206.498	68.92	1.0146413	7.0462
300.837	105.59	1.0225290	7.0587
395.633	147.30	1.0316187	7.0804
500.389	201.75	1.0436866	7.1141

TABLE 3.- Dielectric constants for $He-CO_2$ system at 0° C (con't)

Pressure, (bars)	Density, (moles/cm^3) x 10^2	Dielectric constant	CM^3 (cm^3)
Composition 11.8% He - 88.2% CO_2			
14.14	2.31	1.0008104	0.4540
28.28	4.62	1.0018800	0.4552
42.42	6.93	1.0030400	0.4566
56.56	9.24	1.0043120	0.4579
70.70	11.55	1.0057250	0.4594
84.84	13.86	1.0072750	0.4610
98.98	16.17	1.0089600	0.4627
113.12	18.48	1.0107850	0.4646
127.26	20.79	1.0127500	0.4666
141.40	23.10	1.0148600	0.4688
155.54	25.41	1.0171200	0.4711
169.68	27.72	1.0195250	0.4736
183.82	30.03	1.0220800	0.4762
197.96	32.34	1.0247850	0.4790
212.10	34.65	1.0276400	0.4819
226.24	36.96	1.0306450	0.4850
240.38	39.27	1.0338000	0.4882
254.52	41.58	1.0371050	0.4916
Composition 21.6% He - 78.4% CO_2			
14.14	2.31	1.0008104	0.4540
28.28	4.62	1.0018800	0.4552
42.42	6.93	1.0030400	0.4566
56.56	9.24	1.0043120	0.4579
70.70	11.55	1.0057250	0.4594
84.84	13.86	1.0072750	0.4610
98.98	16.17	1.0089600	0.4627
113.12	18.48	1.0107850	0.4646
127.26	20.79	1.0127500	0.4666
141.40	23.10	1.0148600	0.4688
155.54	25.41	1.0171200	0.4711
169.68	27.72	1.0195250	0.4736
183.82	30.03	1.0220800	0.4762
197.96	32.34	1.0247850	0.4790
212.10	34.65	1.0276400	0.4819
226.24	36.96	1.0306450	0.4850
240.38	39.27	1.0338000	0.4882
254.52	41.58	1.0371050	0.4916
Composition 2.8% He - 97.2% CO_2			
14.14	2.31	1.0008104	0.4540
28.28	4.62	1.0018800	0.4552
42.42	6.93	1.0030400	0.4566
56.56	9.24	1.0043120	0.4579
70.70	11.55	1.0057250	0.4594
84.84	13.86	1.0072750	0.4610
98.98	16.17	1.0089600	0.4627
113.12	18.48	1.0107850	0.4646
127.26	20.79	1.0127500	0.4666
141.40	23.10	1.0148600	0.4688
155.54	25.41	1.0171200	0.4711
169.68	27.72	1.0195250	0.4736
183.82	30.03	1.0220800	0.4762
197.96	32.34	1.0247850	0.4790
212.10	34.65	1.0276400	0.4819
226.24	36.96	1.0306450	0.4850
240.38	39.27	1.0338000	0.4882
254.52	41.58	1.0371050	0.4916

TABLE 2.- Dielectric constants for He-CO_2 system at 0° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM_3, (cm^3)
Composition 48.8% He - 51.2% CO_2			
112.683	34.53	1.0042173	4.0649
209.321	64.66	1.0078546	4.0383
310.116	96.58	1.0117292	4.0320
405.424	127.23	1.0154707	4.0322
502.568	158.92	1.0193624	4.0351
605.863	193.10	1.0235867	4.0396
705.120	226.42	1.0277249	4.0441
659.558	211.07	1.0258186	4.0425
560.635	178.07	1.0217576	4.0433
460.818	145.24	1.0177066	4.0396
354.843	110.91	1.0135013	4.0393
250.112	77.52	1.0094363	4.0446
147.681	45.39	1.0055416	4.0619
48.044	14.64	1.0018312	4.1654
28.589	8.70	1.0011099	4.2508
81.820	25.01	1.0030633	4.0783
235.538	72.91	1.0088503	4.0338
478.618	151.06	1.0183927	4.0336
632.181	201.89	1.0246766	4.0408
371.123	116.15	1.0141424	4.0394
119.546	36.65	1.0044948	4.0809
11.454	3.48	1.0004868	4.6612
Composition 21.6% He - 78.4% CO_2			
116.128	36.25	1.0064692	5.9357
208.062	66.47	1.0118715	5.9294
302.898	99.23	1.0178218	5.9511
397.843	133.82	1.0242149	5.9833
502.514	174.28	1.0318541	6.0282
610.381	218.88	1.0405030	6.0858
704.133	260.36	1.0488194	6.1500
661.479	241.15	1.0449547	6.1219
566.308	200.28	1.0369058	6.0676
454.355	155.34	1.0282949	6.0146
347.809	115.35	1.0208290	5.9770
248.270	80.15	1.0143829	5.9525

Pressure (bars)	Density (moles/cm^3) x 10^2	Dielectric constant	(cm_3) CM^{-3}
	Composition 12.29 Mn - 87.71 CO_2		

TABLE 2.- Dielectric constants for He-CO_2 system at 0° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM, (cm^3)
	Composition 100% CO_2		
122.022	39.38	1.0088512	7.4685
211.984	71.98	1.0162148	7.4684
63.301	19.82	1.0044807	7.5216
100.987	32.24	1.0072414	7.4684
152.392	50.00	1.0112232	7.4539
202.289	68.29	1.0153423	7.4505
495.569	211.63	1.0492694	7.6346
494.823	211.15	1.0492154	7.6439
455.732	186.88	1.0430889	7.5767
411.628	161.95	1.0370405	7.5305
202.289	68.29	1.0153453	7.4519
495.569	211.63	1.0492704	7.6348
353.322	132.33	1.0300776	7.5011
302.686	109.10	1.0246923	7.4822
252.130	87.79	1.0198290	7.4789
204.362	69.07	1.0155577	7.4687
145.963	47.72	1.0107274	7.4659
98.791	31.50	1.0070982	7.4923
45.830	14.23	1.0032526	7.6104
21.064	6.46	1.0015236	7.8560
12.739	3.89	1.0009626	8.2424

Composition 100% CO_2

Pressure, (bars)	Density, (moles/cm^3) x 10^2	Dielectric constant	CM, (cm^3)

TABLE 3.- Dielectric constants for He-CO_2 system at -10° C

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM, (cm^3)
	Composition 100% He		
113.001	35.45	1.0005609	0.5272
207.118	64.76	1.0010197	.5247
305.021	95.02	1.0014916	.5229
403.966	125.39	1.0019725	.5240
505.992	156.46	1.0024623	.5241
604.441	186.23	1.0029352	.5248
703.847	216.07	1.0034070	.5249
802.035	245.33	1.0038658	.5245
908.132	276.71	1.0043567	.5240
1008.249	30.61	1.004815	.5235
954.456	290.33	1.0045680	.5236
852.923	260.41	1.0041012	.5242
749.762	229.78	1.0036214	.5247
648.717	199.55	1.0031475	.5252
550.157	169.85	1.0026807	.5256
442.841	137.26	1.0021688	.5263
344.357	107.12	1.0016929	.5264
244.571	76.36	1.0012111	.5284
162.396	50.86	1.0008114	.5316
39.329	12.37	1.0002073	.5584
23.472	7.39	1.0001292	.5828
151.598	47.50	1.0007553	.5299
325.570	101.35	1.0015928	.5235
478.974	148.26	1.0023241	.5221
625.478	192.56	1.0030133	.5210
777.632	238.08	1.0037225	.5205
932.269	283.81	1.0044328	.5198
983.000	298.71	1.0046652	.5197
828.404	253.15	1.0039560	.5202
673.373	206.94	1.0032387	.5210
519.993	160.71	1.0025174	.5216
376.297	116.92	1.0018352	.5228
221.108	69.10	1.0010879	.5245
69.990	21.99	1.0003546	.5372
11.710	3.68	1.0000691	.6246

Pressure (bars)	Density (moles/cm^3) x 10^2	Dielectric constant	CM (cm^3)
Composition 100% H_2			
0.2553	2.000000	1.000096	33.42
.2553	2.000101	1.000161	33.44
.2553	2.000203	1.000226	33.46
.2553	2.000304	1.000291	33.48
.2553	2.000405	1.000356	33.50
.2553	2.000506	1.000421	33.52
.2553	2.000608	1.000486	33.54
.2553	2.000709	1.000551	33.56
.2553	2.000810	1.000616	33.58
.2553	2.000911	1.000681	33.60
.2553	2.001013	1.000746	33.62
.2553	2.001114	1.000811	33.64
.2553	2.001215	1.000876	33.66
.2553	2.001316	1.000941	33.68
.2553	2.001418	1.001006	33.70
.2553	2.001519	1.001071	33.72
.2553	2.001620	1.001136	33.74
.2553	2.001721	1.001201	33.76
.2553	2.001823	1.001266	33.78
.2553	2.001924	1.001331	33.80
.2553	2.002025	1.001396	33.82
.2553	2.002126	1.001461	33.84
.2553	2.002228	1.001526	33.86
.2553	2.002329	1.001591	33.88
.2553	2.002430	1.001656	33.90
.2553	2.002531	1.001721	33.92
.2553	2.002633	1.001786	33.94
.2553	2.002734	1.001851	33.96
.2553	2.002835	1.001916	33.98
.2553	2.002936	1.001981	34.00
.2553	2.003038	1.002046	34.02
.2553	2.003139	1.002111	34.04
.2553	2.003240	1.002176	34.06
.2553	2.003341	1.002241	34.08
.2553	2.003443	1.002306	34.10
.2553	2.003544	1.002371	34.12
.2553	2.003645	1.002436	34.14
.2553	2.003746	1.002501	34.16
.2553	2.003848	1.002566	34.18
.2553	2.003949	1.002631	34.20
.2553	2.004050	1.002696	34.22
.2553	2.004151	1.002761	34.24
.2553	2.004253	1.002826	34.26
.2553	2.004354	1.002891	34.28
.2553	2.004455	1.002956	34.30
.2553	2.004556	1.003021	34.32
.2553	2.004658	1.003086	34.34
.2553	2.004759	1.003151	34.36
.2553	2.004860	1.003216	34.38
.2553	2.004961	1.003281	34.40
.2553	2.005063	1.003346	34.42
.2553	2.005164	1.003411	34.44
.2553	2.005265	1.003476	34.46
.2553	2.005366	1.003541	34.48
.2553	2.005468	1.003606	34.50
.2553	2.005569	1.003671	34.52
.2553	2.005670	1.003736	34.54
.2553	2.005771	1.003801	34.56
.2553	2.005873	1.003866	34.58
.2553	2.005974	1.003931	34.60
.2553	2.006075	1.003996	34.62
.2553	2.006176	1.004061	34.64
.2553	2.006278	1.004126	34.66
.2553	2.006379	1.004191	34.68
.2553	2.006480	1.004256	34.70
.2553	2.006581	1.004321	34.72
.2553	2.006683	1.004386	34.74
.2553	2.006784	1.004451	34.76
.2553	2.006885	1.004516	34.78
.2553	2.006986	1.004581	34.80
.2553	2.007088	1.004646	34.82
.2553	2.007189	1.004711	34.84
.2553	2.007290	1.004776	34.86
.2553	2.007391	1.004841	34.88
.2553	2.007493	1.004906	34.90
.2553	2.007594	1.004971	34.92
.2553	2.007695	1.005036	34.94
.2553	2.007796	1.005101	34.96
.2553	2.007898	1.005166	34.98
.2553	2.007999	1.005231	35.00
.2553	2.008100	1.005296	35.02
.2553	2.008201	1.005361	35.04
.2553	2.008303	1.005426	35.06
.2553	2.008404	1.005491	35.08
.2553	2.008505	1.005556	35.10
.2553	2.008606	1.005621	35.12
.2553	2.008708	1.005686	35.14
.2553	2.008809	1.005751	35.16
.2553	2.008910	1.005816	35.18
.2553	2.009011	1.005881	35.20
.2553	2.009113	1.005946	35.22
.2553	2.009214	1.006011	35.24
.2553	2.009315	1.006076	35.26
.2553	2.009416	1.006141	35.28
.2553	2.009518	1.006206	35.30
.2553	2.009619	1.006271	35.32
.2553	2.009720	1.006336	35.34
.2553	2.009821	1.006401	35.36
.2553	2.009923	1.006466	35.38
.2553	2.010024	1.006531	35.40
.2553	2.010125	1.006596	35.42
.2553	2.010226	1.006661	35.44
.2553	2.010328	1.006726	35.46
.2553	2.010429	1.006791	35.48
.2553	2.010530	1.006856	35.50
.2553	2.010631	1.006921	35.52
.2553	2.010733	1.006986	35.54
.2553	2.010834	1.007051	35.56
.2553	2.010935	1.007116	35.58
.2553	2.011036	1.007181	35.60
.2553	2.011138	1.007246	35.62
.2553	2.011239	1.007311	35.64
.2553	2.011340	1.007376	35.66
.2553	2.011441	1.007441	35.68
.2553	2.011543	1.007506	35.70
.2553	2.011644	1.007571	35.72
.2553	2.011745	1.007636	35.74
.2553	2.011846	1.007701	35.76
.2553	2.011948	1.007766	35.78
.2553	2.012049	1.007831	35.80
.2553	2.012150	1.007896	35.82
.2553	2.012251	1.007961	35.84
.2553	2.012353	1.008026	35.86
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.2553	2.053663	1.034546	44.02
.2553	2.053764	1.034611	44.04
.2553	2.053865	1.034676	44.06
.2553	2.053966	1.034741	44.08
.2553	2.054068	1.034806	44.10
.2553	2.054169	1.034871	44.12
.2553	2.054270	1.034936	44.14
.2553	2.054371	1.035001	44.16
.2553	2.054473	1.035066	44.18
.2553	2.054574	1.035131	44.20
.2553	2.054675	1.035196	44.22
.2553	2.054776	1.035261	44.24
.2553	2.054878	1.035326	44.26
.2553	2.054979	1.035391	44.28
.2553	2.055080	1.035456	44.30
.2553	2.055181	1.035521	44.32
.2553	2.055283	1.035586	44.34
.2553	2.055384	1.035651	44.36
.2553	2.055485	1.035716	44.38
.2553	2.055586	1.035781	44.40
.2553	2.055688	1.035846	44.42
.2553	2.055789	1.035911	44.44
.2553	2.055890	1.035976	44.46
.2553	2.055991	1.036041	44.48
.2553	2.056093	1.036106	44.50
.2553	2.056194	1.036171	44.52
.2553	2.056295	1.036236	44.54
.2553	2.056396	1.036301	44.56
.2553	2.056498	1.036366	44.58
.2553	2.056599	1.036431	44.60
.2553	2.056700	1.036496	44.62
.2553	2.056801	1.036561	44.64
.2553	2.056903	1.036626	44.66
.2553	2.057004	1.036691	44.68
.2553	2.057105	1.036756	44.70
.2553	2.057206	1.036821	44.72
.2553	2.057308	1.036886	44.74
.2553	2.057409	1.036951	44.76
.2553	2.057510	1.037016	44.78
.2553	2.057611	1.037081	44.80
.2553	2.057713	1.037146	44.82
.2553	2.057814	1.037211	44.84
.2553	2.057915	1.037276	44.86
.2553	2.058016	1.037341	44.88
.2553	2.058118	1.037406	44.90
.2553	2.058219	1.037471	44.92
.2553	2.058320	1.037536	44.94
.2553	2.058421	1.037601	44.96
.2553	2.058523	1.037666	44.98
.2553	2.058624	1.037731	45.00
.2553	2.058725	1.037796	45.02
.2553	2.058826	1.037861	45.04
.2553	2.058928	1.037926	45.06
.2553	2.059029	1.037991	45.08
.2553	2.059130	1.038056	45.10
.2553	2.059231	1.038121	45.12
.2553	2.059333	1.038186	45.14
.2553	2.059434	1.038251	45.16
.2553	2.059535	1.038316	45.18
.2553	2.059636	1.

TABLE 3.- Dielectric constants for He-CO_2 system at -10° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM_3, (cm^3)
	Composition 94.72% He - 5.28% CO_2		
512.170	158.26	1.0042054	0.8844
407.920	126.55	1.0033659	.8855
297.178	92.58	1.0024663	.8872
199.141	62.27	1.0016619	.8890
98.808	31.01	1.0008464	.9093
43.006	13.52	1.0003796	.9352
11.280	3.55	1.0001132	1.0618
162.004	50.73	1.0013443	.8828
254.755	79.49	1.0021007	.8802
353.203	109.80	1.0028971	.8786
452.198	140.05	1.0036885	.8768
550.372	169.82	1.0044719	.8764
576.004	177.55	1.0046752	.8763
486.282	150.41	1.0039630	.8770
384.435	119.37	1.0031485	.8782
227.568	71.08	1.0018873	.8844
150.995	47.30	1.0012602	.8876
122.450	38.40	1.0010268	.8908
76.658	24.08	1.0006481	.8967
26.752	8.42	1.0002374	.9396
	Composition 88.5% He - 11.5% CO_2		
116.691	36.62	1.0014435	1.3132
211.368	66.11	1.0025946	1.3070
304.802	95.02	1.0037195	1.3031
405.933	126.10	1.0049337	1.3020
505.711	156.54	1.0061558	1.3080
602.644	185.90	1.0072858	1.3031
702.459	215.92	1.0084389	1.2990
807.261	247.21	1.0096610	1.2984
903.025	275.59	1.0107780	1.2989
1000.517	304.28	1.011902	1.2987
956.898	291.47	1.0114021	1.2990
860.673	263.06	1.0102881	1.2991
753.197	231.10	1.0090379	1.2996
649.230	199.94	1.0078198	1.3002

Pressure (bars)	Density (moles/cm^3) x 10^3	Dielectric constant	CH_4 (cm^3)
Composition 97.52 % H_2 - 2.48 % CO_2			
1.0132	0.0404	1.000548	24.69
10.132	0.4042	1.005482	24.73
20.265	0.8084	1.010960	24.78
30.397	1.2126	1.016500	24.83
40.530	1.6168	1.022100	24.88
50.662	2.0210	1.027760	24.93
60.795	2.4252	1.033480	24.98
70.927	2.8294	1.039260	25.03
81.060	3.2336	1.045100	25.08
91.192	3.6378	1.051000	25.13
101.325	4.0420	1.056960	25.18
Composition 84.752 % H_2 - 15.248 % CO_2			
1.0132	0.0404	1.000548	24.69
10.132	0.4042	1.005482	24.73
20.265	0.8084	1.010960	24.78
30.397	1.2126	1.016500	24.83
40.530	1.6168	1.022100	24.88
50.662	2.0210	1.027760	24.93
60.795	2.4252	1.033480	24.98
70.927	2.8294	1.039260	25.03
81.060	3.2336	1.045100	25.08
91.192	3.6378	1.051000	25.13
101.325	4.0420	1.056960	25.18

TABLE 3.- Dielectric constants for H_2-CO_2 system at -10° C (Cou')

TABLE 3.- Dielectric constants for He-CO_2 system at -10° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM, (cm^3)
Composition 88.5% He - 11.5% CO_2			
551.267	170.36	1.0066657	1.3012
443.938	137.72	1.0053895	1.3020
349.304	108.72	1.0042585	1.3036
245.568	76.71	1.0030113	1.3070
143.610	45.02	1.0017801	1.3169
123.082	38.61	1.0015296	1.3196
77.650	24.40	1.0009737	1.3295
45.351	14.26	1.0005780	1.3500
23.762	7.48	1.0003165	1.4102
11.243	3.54	1.0001602	1.5084
Composition 71.91% He - 28.09% CO_2			
117.418	36.98	1.0027569	2.4823
214.293	67.46	1.0050098	2.4709
305.268	96.06	1.0071346	2.4697
404.499	127.21	1.0094547	2.4696
501.283	157.54	1.0117237	2.4709
593.779	186.47	1.0138845	2.4705
712.547	223.53	1.0166294	2.4660
792.785	248.51	1.0184976	2.4658
902.846	282.69	1.0211934	2.4814
1008.945	315.53	1.023707	2.4848
959.803	300.33	1.0225799	2.4873
860.369	269.51	1.0202417	2.4866
738.375	231.58	1.0173636	2.4848
640.588	201.09	1.0150666	2.4849
531.980	167.14	1.0125111	2.4846
436.083	137.11	1.0102521	2.4838
338.284	106.43	1.0079641	2.4876
238.723	75.15	1.0056339	2.4942
147.812	46.55	1.0035192	2.5169
303.840	95.61	1.0071546	2.4882
501.594	157.63	1.0117698	2.4790
747.735	234.49	1.0175279	2.4770
988.645	309.26	1.0231509	2.4761
678.318	212.86	1.0158139	2.4633

TABLE 3.- Dielectric constants for $He-CO_2$ mixtures at -10° C (Con.)

Pressure (bars)	Density ($moles/cm^3$) x 10^2	Dielectric constant	CM^{-1} (cm^3)
Composition 88.2% He - 11.2% CO_2			
152.581	10.36	1.0008951	1.3015
443.838	12.345	1.0023695	1.3050
344.304	10.543	1.0042582	1.3039
242.208	17.17	1.0030113	1.3010
143.810	12.03	1.0017801	1.2969
153.083	18.38	1.0012536	1.2918
77.820	24.40	1.0007616	1.2852
52.351	14.32	1.0002180	1.2800
33.193	7.84	1.0001615	1.2704
11.243	3.24	1.0000503	1.2084
Composition 17.19% He - 82.80% CO_2			
778.816	38.512	1.0158136	1.3433
388.248	30.605	1.0052520	1.3414
171.476	25.125	1.0025710	1.3376
102.582	12.121	1.0012110	1.3324
61.565	14.581	1.0014880	1.3284
41.212	12.345	1.0012586	1.3248
28.196	10.284	1.0010482	1.3208
18.506	8.224	1.0008378	1.3164
11.256	6.164	1.0006274	1.3120
6.848	4.104	1.0004170	1.3076
4.164	2.044	1.0002066	1.3032
2.532	1.024	1.0001035	1.3010
1.540	0.512	1.0000518	1.2988
0.937	0.256	1.0000259	1.2966
0.570	0.128	1.0000130	1.2944
0.347	0.064	1.0000065	1.2922
0.211	0.032	1.0000032	1.2900

TABLE 3.- Dielectric constants for He-CO_2 system at -10° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM, (cm^3)
	Composition 71.91% He - 28.09% CO_2		
315.201	99.18	1.0074111	2.4845
73.860	23.26	1.0017801	2.5484
10.779	3.39	1.0003005	2.9489
	Composition 51.98% He - 48.02% CO_2		
468.216	153.10	1.0176522	3.8206
407.393	132.58	1.0152800	3.8219
298.067	96.18	1.0110716	3.8228
195.288	62.50	1.0072047	3.8327
90.935	28.86	1.0033489	3.8628
11.920	3.76	1.0004888	4.3330
605.248	200.00	1.0230838	3.8178
518.898	170.34	1.0196377	3.8178
703.734	234.28	1.0270918	3.8200
803.514	269.50	1.0312372	3.8236
909.225	307.35	1.0357211	3.8284
947.578	321.21	1.0373620	3.8294
861.774	290.29	1.0337035	3.8269
754.709	252.21	1.0292366	3.8266
643.397	213.22	1.0246616	3.8239
545.721	179.51	1.0207166	3.8204
449.224	146.67	1.0168998	3.8190
336.260	108.83	1.0125271	3.8208
239.641	76.97	1.0088566	3.8239
141.706	45.16	1.0052282	3.8518
48.014	15.18	1.0017932	3.9329
	Composition 21.5% He - 78.5% CO_2		
115.308	37.63	1.0067499	5.9654
209.004	70.31	1.0126083	5.9519
298.973	103.79	1.0186800	5.9621
394.564	142.03	1.0257024	5.9808
490.960	184.00	1.0335142	6.0041
544.118	208.91	1.0375022	5.9096
469.595	174.36	1.0318543	6.0255

CH_4 (cm^3)	Diffusion coefficient (cm^2/sec)	Density (moles/cm^3) x 10^2	Pressure (bars)
CO_2 - 18.2% H_2 - 81.8% CO_2 mixture			
0	1.0000E-5	4.46	1.01
0.5	9.9000E-6	4.46	1.01
1.0	9.8000E-6	4.46	1.01
1.5	9.7000E-6	4.46	1.01
2.0	9.6000E-6	4.46	1.01
2.5	9.5000E-6	4.46	1.01
3.0	9.4000E-6	4.46	1.01
3.5	9.3000E-6	4.46	1.01
4.0	9.2000E-6	4.46	1.01
4.5	9.1000E-6	4.46	1.01
5.0	9.0000E-6	4.46	1.01
CO_2 - 35.6% H_2 - 64.4% CO_2 mixture			
0	1.0000E-5	3.42	1.01
0.5	9.9000E-6	3.42	1.01
1.0	9.8000E-6	3.42	1.01
1.5	9.7000E-6	3.42	1.01
2.0	9.6000E-6	3.42	1.01
2.5	9.5000E-6	3.42	1.01
3.0	9.4000E-6	3.42	1.01
3.5	9.3000E-6	3.42	1.01
4.0	9.2000E-6	3.42	1.01
4.5	9.1000E-6	3.42	1.01
5.0	9.0000E-6	3.42	1.01
CO_2 - 51.2% H_2 - 48.8% CO_2 mixture			
0	1.0000E-5	2.64	1.01
0.5	9.9000E-6	2.64	1.01
1.0	9.8000E-6	2.64	1.01
1.5	9.7000E-6	2.64	1.01
2.0	9.6000E-6	2.64	1.01
2.5	9.5000E-6	2.64	1.01
3.0	9.4000E-6	2.64	1.01
3.5	9.3000E-6	2.64	1.01
4.0	9.2000E-6	2.64	1.01
4.5	9.1000E-6	2.64	1.01
5.0	9.0000E-6	2.64	1.01
CO_2 - 64.9% H_2 - 35.1% CO_2 mixture			
0	1.0000E-5	2.11	1.01
0.5	9.9000E-6	2.11	1.01
1.0	9.8000E-6	2.11	1.01
1.5	9.7000E-6	2.11	1.01
2.0	9.6000E-6	2.11	1.01
2.5	9.5000E-6	2.11	1.01
3.0	9.4000E-6	2.11	1.01
3.5	9.3000E-6	2.11	1.01
4.0	9.2000E-6	2.11	1.01
4.5	9.1000E-6	2.11	1.01
5.0	9.0000E-6	2.11	1.01

TABLE 3.- Diffusion coefficients for H_2-CO_2 system at -10° C (Cem')

TABLE 3.- Dielectric constants for $He-CO_2$ system at -10° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM, (cm^3)
	Composition 21.5% He - 78.5% CO_2		
347.213	122.71	1.0222443	5.9979
245.960	83.79	1.0151197	5.9841
136.580	44.87	1.0080903	5.9933
43.336	13.83	1.0025485	6.1356
84.780	27.40	1.0049548	6.0161
287.712	99.47	1.0179136	5.9670
439.573	161.15	1.0292517	5.9918
525.508	200.03	1.0365746	6.0211
321.608	112.57	1.0203439	5.9830
120.223	39.29	1.0070865	5.9969
28.695	9.11	1.0017170	6.2722
11.461	3.62	1.0007383	6.7890
188.263	62.90	1.0112868	5.9587
119.615	39.09	1.0070243	5.9758
78.191	25.22	1.0045550	6.0098
55.930	17.92	1.0032577	6.0524
34.948	11.12	1.0020576	6.1591
23.161	7.34	1.0013844	6.2765
505.482	190.67	1.0348192	6.0171
368.671	131.37	1.0237818	5.9868
239.517	81.42	1.0146477	5.9674
161.539	53.50	1.0096159	5.9717
117.679	38.43	1.0069202	5.9879
77.186	24.89	1.0045099	6.0297
51.289	16.41	1.0029983	6.0836
34.452	10.96	1.0020336	6.1759
17.528	5.55	1.0010678	6.4086
553.510	213.47	1.0387260	5.9699
384.355	137.80	1.0254728	6.1098
261.702	89.65	1.0164509	6.0831
190.000	63.51	1.0116244	6.0766
128.054	41.95	1.0076915	6.0945
93.541	30.32	1.0055768	6.1193
41.636	13.28	1.0025054	6.2814
110.754	36.09	1.0064902	5.9808
209.178	70.37	1.0126428	5.9628
302.350	105.09	1.0189627	5.9768

Frequency (hertz)	Density (moles/cm^3) x 10_2	Dielectric constant	CM (cm^3/
	Composition 51.5% Na - 18.5% CO^5		

TABLE 3.- Dielectric constants for $He-CO_2$ system at -10° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM, (cm^3)
	Composition 21.5% He - 78.5% CO_2		
395.048	142.23	1.0258005	5.9949
494.662	185.69	1.0339064	6.0183
494.600	185.66	1.0339014	6.0183
430.121	157.07	1.0285462	6.0007
347.622	122.87	1.0222293	5.9859
232.168	78.72	1.0141644	5.9692
156.810	51.85	1.0093110	5.9664
103.854	33.77	1.0060705	5.9794
45.420	14.50	1.0026375	6.0544
	Composition 11.67% He - 88.33% CO_2		
45.135	14.48	1.0029943	6.8827
111.250	36.72	1.0074111	6.7108
150.927	50.70	1.0101940	6.6793
198.093	68.01	1.0136831	6.6751
243.440	85.47	1.0172174	6.6762
295.931	106.81	1.0215630	6.6813
342.196	126.79	1.0256662	6.6902
389.335	148.49	1.0301682	6.7045
375.426	141.93	1.0288328	6.7067
322.602	118.18	1.0239102	6.6904
279.481	99.98	1.0201846	6.6844
223.913	77.85	1.0156847	6.6805
172.822	58.64	1.0118028	6.6828
117.356	38.83	1.0078248	6.6980
78.464	25.53	1.0051611	6.7249
26.176	8.33	1.0017470	6.9813
11.821	3.74	1.0008485	7.5541
	Composition 6.72% He - 93.28% CO_2		
223.615	78.92	1.0167265	7.0247
103.966	34.41	1.0073199	7.0730
25.010	7.97	1.0018062	7.5476
10.878	3.44	1.0008635	8.3527
84.234	27.61	1.0058904	7.0967
180.964	62.34	1.0132003	7.0262

TABLE 3.- Dielectric constants for H_2-CO_2 system at -10° C (Con.)

Pressure, (bars)	Density, (moles/cm^3) x 10^2	Dielectric constant	$(CM)_3$
Composition 11.2% H_2 - 88.8% CO_2			
2.0244	14.20	1.0052312	2.0244
2.1647	14.33	1.0060102	2.1647
2.3097	14.47	1.0067900	2.3097
2.4596	14.61	1.0075744	2.4596
2.6146	14.75	1.0083633	2.6146
2.7750	14.89	1.0091580	2.7750
2.9410	15.03	1.0099600	2.9410
3.1131	15.18	1.0107690	3.1131
3.2916	15.33	1.0115850	3.2916
3.4768	15.48	1.0124100	3.4768
3.6691	15.63	1.0132450	3.6691
3.8688	15.78	1.0140900	3.8688
4.0763	15.93	1.0149450	4.0763
4.2919	16.08	1.0158100	4.2919
4.5161	16.24	1.0166850	4.5161
4.7492	16.40	1.0175710	4.7492
4.9916	16.56	1.0184700	4.9916
Composition 11.5% H_2 - 88.5% CO_2			
2.0244	14.20	1.0052312	2.0244
2.1647	14.33	1.0060102	2.1647
2.3097	14.47	1.0067900	2.3097
2.4596	14.61	1.0075744	2.4596
2.6146	14.75	1.0083633	2.6146
2.7750	14.89	1.0091580	2.7750
2.9410	15.03	1.0099600	2.9410
3.1131	15.18	1.0107690	3.1131
3.2916	15.33	1.0115850	3.2916
3.4768	15.48	1.0124100	3.4768
3.6691	15.63	1.0132450	3.6691
3.8688	15.78	1.0140900	3.8688
4.0763	15.93	1.0149450	4.0763
4.2919	16.08	1.0158100	4.2919
4.5161	16.24	1.0166850	4.5161
4.7492	16.40	1.0175710	4.7492
4.9916	16.56	1.0184700	4.9916
Composition 11.8% H_2 - 88.2% CO_2			
2.0244	14.20	1.0052312	2.0244
2.1647	14.33	1.0060102	2.1647
2.3097	14.47	1.0067900	2.3097
2.4596	14.61	1.0075744	2.4596
2.6146	14.75	1.0083633	2.6146
2.7750	14.89	1.0091580	2.7750
2.9410	15.03	1.0099600	2.9410
3.1131	15.18	1.0107690	3.1131
3.2916	15.33	1.0115850	3.2916
3.4768	15.48	1.0124100	3.4768
3.6691	15.63	1.0132450	3.6691
3.8688	15.78	1.0140900	3.8688
4.0763	15.93	1.0149450	4.0763
4.2919	16.08	1.0158100	4.2919
4.5161	16.24	1.0166850	4.5161
4.7492	16.40	1.0175710	4.7492
4.9916	16.56	1.0184700	4.9916
Composition 12.1% H_2 - 87.9% CO_2			
2.0244	14.20	1.0052312	2.0244
2.1647	14.33	1.0060102	2.1647
2.3097	14.47	1.0067900	2.3097
2.4596	14.61	1.0075744	2.4596
2.6146	14.75	1.0083633	2.6146
2.7750	14.89	1.0091580	2.7750
2.9410	15.03	1.0099600	2.9410
3.1131	15.18	1.0107690	3.1131
3.2916	15.33	1.0115850	3.2916
3.4768	15.48	1.0124100	3.4768
3.6691	15.63	1.0132450	3.6691
3.8688	15.78	1.0140900	3.8688
4.0763	15.93	1.0149450	4.0763
4.2919	16.08	1.0158100	4.2919
4.5161	16.24	1.0166850	4.5161
4.7492	16.40	1.0175710	4.7492
4.9916	16.56	1.0184700	4.9916

TABLE 3.- Dielectric constants for He-CO_2 system at -10° C (Con.)

Pressure, (psia)	Density, (moles/cm^3) x 10^5	Dielectric constant	CM, (cm^3)
Composition 6.72% He - 93.28% CO_2			
273.025	99.32	1.0210642	7.0197
317.412	118.94	1.0252977	7.0304
375.936	147.10	1.0314335	7.0490
389.646	154.14	1.0329802	7.0543
354.390	136.39	1.0291094	7.0457
308.012	114.67	1.0243941	7.0336
247.773	88.72	1.0188172	7.0250
202.202	70.49	1.0149434	7.0307
149.364	50.59	1.0107219	7.0384
120.000	40.04	1.0084980	7.0545
43.683	14.04	1.0030674	7.2721
Composition 100% CO_2			
51.183	16.59	1.0037646	7.5522
305.634	118.23	1.0268321	7.4973
268.722	100.67	1.0227760	7.4842
228.735	83.03	1.0187289	7.4719
185.140	65.14	1.0146557	7.4625
143.511	49.13	1.0110304	7.4550
104.790	35.04	1.0078738	7.4702
58.045	18.89	1.0042675	7.5186
24.791	7.92	1.0018312	7.7018
87.007	28.79	1.0064583	7.4606
125.292	42.41	1.0095007	7.4422
166.844	57.99	1.0130139	7.4478
203.895	72.68	1.0163287	7.4475
252.831	93.50	1.0211191	7.4758
283.781	107.67	1.0243688	7.4829
323.613	127.31	1.0289028	7.4950
342.909	137.49	1.0313080	7.5118
332.516	131.95	1.0300177	7.5078
187.498	66.08	1.0148721	7.4648
78.085	25.70	1.0057892	7.4920
13.153	4.17	1.0009947	7.9386

Pressure (bars)	Density (moles/cm^3) x 10^2	Diffusivity constant	Cm^2 (cm^3)
Composition 100% CO_2			
4.83	12.04	1.0025045	1.5151
150.000	40.04	1.0088480	1.0242
149.364	39.87	1.0151010	1.0384
505.505	49.49	1.0154454	1.0701
514.277	38.53	1.0188101	1.0550
308.015	110.19	1.0524361	1.0230
332.390	136.36	1.0601850	1.0240
386.444	124.11	1.0255805	1.0243
315.439	141.01	1.0163433	1.0490
314.514	118.46	1.0525250	1.0304
513.052	96.35	1.0510052	1.0191

Composition 4.153% He - 95.847% CO_2

TABLE 3.- Diffusivity constants for He-CO_2 system at -10° C (Con't)